GEOLOGIAN TUTKIMUSKESKUS **GEOLOGICAL SURVEY OF FINLAND**

Tutkimusraportti 146 Report of Investigation 146

Pasi Eilu

FINGOLD - A PUBLIC DATABASE ON GOLD DEPOSITS IN FINLAND

Tiivistelmä: FINGOLD - julkinen tietokanta Suomen kultaesiintymistä

Geologian tutkimuskeskus
Espoo 1999

Eilu, Pasi 1999. FINGOLD - a public database on gold deposits in Finland. Tiivistelmä: FINGOLD - julkinen tietokanta Suomen kultaesiintymistä. *Geologian tutkimuskeskus, Tutkimusraportti - Geological Survey of Finland, Report of Investigation 146.* 224 pages, 1 figure, 1 table and 2 appendes .

FINGOLD is a public-domain geoscience database containing all bedrock gold deposits and significant gold prospects in Finland. The database is in ACCESS® format and, presently (31/12/1998), it contains information on 131 mineralisations. Included are both gold-only types and cases where gold is the main commodity. To be included, a prospect must contain at least 1 ppm Au (i.e. 1 g/t) for a 1 m section or at least 0.5 ppm Au for a 5 m section across the mineralisation in bedrock. All significant aspects of the deposits and prospects, especially aspects concerning exploration, are covered by six internally linked tables in the database. Entries contain references to all published literature and other primary sources of data.

The contents of the database as 31/12/1998 are presented in this report. FINGOLD is also available on CD-ROM and accessible on the Internet through the exploration pages of the Geological Survey of Finland, as well as a large number of photographs, maps and other figures on the deposits and prospects.

Key words (GeoRef Thesaurus, AGI): economic geology, gold ores, data bases, FINGOLD, mining, mineral exploration, host rocks, metamorphism, structural analysis, hydrothermal alteration, mineral deposits, genesis, Paleoproterozoic, Archean, Finland

Pasi Eilu
Department of Geology,
University of Turku
FIN-20014 TURKU, FINLAND

E-mail: pasi.eilu@utu.fi

ISBN 951-690-731-8
ISSN 07 81-4240

Eilu, Pasi 1999. FINGOLD - a public database on gold deposits in Finland. Tiivistelmä: FINGOLD - julkinen tietokanta Suomen kultaesiintymistä. *Geologian tutkimuskeskus, Tutkimusraportti - Geological Survey of Finland, Report of Investigation 146.* 224 sivua, 1 kuva, 1 taulukko ja 2 liitettä.

FINGOLD on julkinen geologian alan tietokanta, joka sisältää kuvauksen kaikista Suomen kallioperässä todetuista kultamalmeista ja -esiitymistä. Tietokantaohjelmana on käytetty ACCESS® -ohjelmaa. Tietokanta sisältää tiedot 131 kohteesta. Kohteissa kulta on ainoa tai tärkein arvometalli. Tietokantaan otetussa esiintymässä tulee olla vähintään 1 ppm Au 1 m leveydeltä tai vähintään 0.5 ppm Au 5 m leveydeltä poikki kallioperässä olevan kultaesiintymän. Tietokannassa on kaikki merkittävä tieto kustakin kohteesta, erityisesti kaikki sellainen aineisto, joka liittyy malminetsintään. Nämä tiedot ovat kuudessa keskenään linkitetyssä taulukossa. Kaikkeen aineistoon on annettu viitteet julkaisuihin ja muihin alkuperäisiin lähteisiin.

Tietokannan sisältö on esitetty tässä raportissa päivitettynä 31.12. 1998. FINGOLD on myös saatavissa CD-ROM:lla ja tutkittavissa Geologian tutkimuskeskuksen malminetsinnän internet-sivuilla (www.gsf.fi/explor), joilla on myös suuri määrä valokuvia, geologisia karttoja ja muita kuvia tietokannan kohteista.

Julkaisu on englanninkielinen.

Avainsanat (Fingeo-sanasto, GTK): malmigeologia, kultamalmit, tietokannat, FINGOLD, louhinta, malminetsintä, isäntäkivet, metamorfoosi, rakenneanalyysi, hydroterminen muuttuminen, mineraaliesiintymien synty, paleoproterotsooinen, arkeeinen, Suomi

Pasi Eilu
Geologian laitos,
Turun yliopisto
20014 TURKU

Sähköposti: pasi.eilu@utu.fi

CONTENTS

PREFACE

This paper is the first major report of the research project 'Documentation and Modelling of Gold Mineralisation in Finland', a joint project between the Geological Survey of Finland (GTK) and the Department of Geology, University of Turku, Finland. The duration of the project is from August 1997 to December 1999, and it is partially funded by the Ministry of Trade and Industry of Finland (MTI).

This report presents an extensive collection of new, largely unpublished information on all gold-only and gold-dominated deposits in Finland. The FINGOLD database in which this information is stored forms an integral part of the geological databases available to the public from the GTK and is intended for gold research and exploration. The database is also accessible through the Internet pages of the GTK (http://www.gsf.fi) and is, also, available on CD-ROM. Background information of the project and a detailed description of the database are given below. Current contents, as updated on December 31, 1998, are given at the end of this report (App. 1 and 2).

.

EXPLORATION FOR GOLD IN FINLAND

Up to the end of the 1970's, only a few gold mineralisations of any significance were known in the Fennoscandian Shield and there were no clear ideas about the regional potential (Nurmi 1991 and 1993, Puustinen 1991). Rather, it was commonly thought, although perhaps not so commonly officially stated, that the potential for significant gold mineralisation was low throughout the shield (Gaal and Sundblad 1990, Puustinen 1991). In Finland, only two deposits, Haveri and Kivimaa (Fig. 1), were mined chiefly for gold with copper as a significant byproduct (Rouhunkoski and Isokangas 1974, Mäkelä 1980). This perception has slowly but radically changed since the early 1980's due to two major reasons: increase in the price of gold and extensive research on the genesis and exploration methods of gold mineralisation. The former has been the main reason for the increase in exploration activity in practically all orogenic belts in the world. The latter has shown that any Precambrian shield - in fact any orogenic belt - and any rock type may host significant gold mineralisation, and has provided new genetic models which can be directly applied to exploration.

Especially important has been research on orogenic or 'mesothermal, lode-, vein-metamorphogenic, structurally-hosted' gold mineralisation summarised by, among others, Colvine et al. (1988), Colvine (1989), Goldfarb et al. (1998), Groves et al. (1998), and McCuaig and Kerrich (1998). Significant progress has also recently taken place in research of practically all other types of gold mineralisation as summarised by, for example, Berger and Bagby (1991), Sillitoe (1991), Hedenquist et al. (1996), Davidson (1998), and Ferenczi and Ahmad (1998). The significance of these other deposit types perhaps has not yet fully appreciated in Precambrian shields, as the clearly dominant 'mesothermal' type has, in most cases, been the sole target in gold exploration. Also important has been the development in analytical methods which has made possible cheap and reliable gold and pathfinder element analyses with very low detection limits, e.g. the flameless graphite furnace atom absorption spectrometry (GAAS) and the ICP-MS (e.g., Kontas 1981, Niskavaara and Kontas 1990).

Modern exploration methods were not applied to gold exploration in Finland until the early 1980's. However, recent investments have led to the discovery of, at least, 140 drilling-indicated deposits, three of which have been opened as new mines (Saattopora, Pahtavaara and Kutemajärvi; Fig. 1), and a number of others that are undergoing or have undergone extensive feasibility studies (e.g., Juomasuo, Pampalo and Suurikuusikko; Fig. 1). Simultaneously, it has become evident that large parts of Finland, both in the Proterozoic and Archaean domains, are potential and still under-explored for gold mineralisation. Recent research has also revealed the genetic types of the deposits more precisely and in some cases shown that the wrong genetic models were previously ascribed to a number of the deposits.

BACKGROUND FOR THE PRESENT PROJECT AND THIS REPORT

A large number of reports on gold mineralisation and exploration in Finland have been written during the past 15 years. Although most of these reports are public, the majority are not publicised, available only in the archives of the GTK, MTI, other institutions and mining companies. In addition, there has not been a comprehensive presentation of all major aspects of gold mineralisations in Finland. There are high-quality scientific and technical papers on individual deposits or 'gold belts' (e.g., Korkiakoski 1992, Pankka and Vanhanen 1992, Nurmi and Sorjonen-Ward 1993, Kontoniemi and Nurmi 1998) and summaries on certain, limited aspects of the gold mineralisations (e.g. Nurmi et al. 1991, Puustinen 1991, Sorjonen-Ward and Nurmi 1997). From this material, it is difficult for an outsider to get a reliable, comprehensive picture, although a large number of details are well-

Fig. 1. Distribution of the gold mines, deposits with significant proven resources and prospects included in the FINGOLD database. Names of the geological subdomains (greenstone and schist belts and other areas) used in the database are in italics and their extent marked by heavy boundary lines.

presented.

The present project was set up to answer these needs, especially to create a comprehensive view of the potential of gold mineralisation in Finland in such a way that all parameters important in exploration are presented in a clear, systematic way. This presentation will also give better chances to develop research, for example, to test new hypotheses on the formation of and exploration on gold mineralisation. The ultimate purpose for the project and its products is to increase exploration activity in and get investments to Finland. Presentations of similar type have previously been done for other gold-producing Precambrian areas, for example, for certain provinces of Canada and states of Australia (Anonymous 1984, Lefebure and Ray 1995, Richardson and Ostry 1996, VanderHor and Groves 1998). The styles and level of detail of these reviews are applied here where seen useful. The best model for the FINGOLD database has been that of gold deposits of Western Australia (VanderHor and Groves 1998).

DESCRIPTION AND ORGANISATION OF THE FINGOLD DATABASE

FINGOLD is a public-domain geoscience database containing all gold deposits and significant showings detected in bedrock in Finland. Presently (31/12/1998), it contains information on 131 mineralisations. Included are both gold-only types and cases where gold is the main commodity. To be included, a prospect must contain at least 1 ppm Au (i.e. 1 g/t) for a 1 m section or at least 0.5 ppm Au for a 5 m section across the mineralisation in bedrock. Due to this definition, for example, the small placer deposits of northern Finland are not included, nor are the numerous showings of gold that are only detected in the overburden, chiefly in till, throughout Finland.

FINGOLD (in ACCESS® format) contains the following information on each deposit/prospect: location, discovery, holding, exploration and mining history, deposit and wallrock geology, mineralogy, geochemistry and geophysical features, and genetic modelling are covered by six internally linked tables, as follows:

1. Deposit: Location, infrastructure, present and previous holders, links to figures and maps.

2. Exploration and mining (when, by whom and by which methods): Discovery, exploration history, status of development, number and size of lodes, extent of mineralisation, resources, best sections, elements analysed, drilling, response by geophysical methods, primary and secondary geochemical dispersion (anomalies detected), economic evaluations, geologist(s) in charge of exploration.

3. Ore: Siting and fineness of gold, major and minor ore minerals, gangue minerals, elements enriched in ore, bulk ore composition, ore fluid and isotope data, timing of mineralisation, genetic type, genetic model.

4. Structure and alteration: Structural style, closest major shear or fault zone, controlling structure(s), veins, deformation history of the area, ore fabric, alteration style and zoning, post-mineralisation modification.

5. Geology: Regional and local geological domain, geological setting, major and minor host rocks, intrusives in the area, metamorphic grade and history of the area, metamorphic mineral assemblages (in unaltered rocks).

6. References.

All entries have references to published literature or other primary sources of data. The latter include, i.e., unpublished technical reports, MSc theses, personal communications and press releases. The structure of each deposit presentation in this report is given in Appendix 1 and the contents of the database as of 31/12/1998 in Appendix 2. All mineralisations presently included in the database are also listed in Table 1 according to genetic type and geological domain, and their geographical distribution is shown in Figure 1.

FINGOLD is also available on CD-ROM and accessible via the Internet through the exploration pages of the Geological Survey of Finland (www.gsf.fi/explor). A large number of photographs, maps and other figures are accessible in these versions of the database.

Table 1. Deposits in the FINGOLD database classified according to genetic type, major geological domain and subdomain. ID no. refers to the identification number for each deposit in the database. Page refers to the page number of the full report for each deposit given in Appendix 2. Major host rock and status of development at the end of 1998 are also given. Alternative names of the deposits are given in brackets. The 'Mesothermal type' as used here is equivalent to the orogenic lode-gold deposit *sensu* Gebre-Mariam et al. (1995) and Groves et al. (1998). For the location of the geological domains, subdomains and the most significant deposits, see Figure 1.

Orogenic 'mesothermal'

Archaean

Ilomantsi Greenstone Belt

Name	*ID no.*	*Page*	*Major host rock(s)*	*Status*
Elinsuo	11	17	Mica schist	Prospect
Kelokorpi	13	19	Intermediate metatuffite	Prospect
Kivisuo	8	21	Mica schist	Prospect
Korpilampi	12	23	Intermediate schist (tuffite)	Prospect
Korvilansuo	7	25	Mica schist	Prospect
Kuittila	5	27	Tonalite	Prospect
Kuivisto	65	29	Intermediate schist (tuffite)	Prospect
Muurinsuo	6	30	Mica schist (volcanogenic metasedimentary rock)	Prospect
Pampalo (Ward)	1	32	Intermediate metatuffite	Pilot mining
Rämepuro	4	35	Tonalitic porphyry dyke	Prospect
Valkeasuo (Hosko)	10	37	Mica schist (intermediate metatuffite?)	Prospect
Viinivaara	9	39	Mica schist	Prospect

Kuhmo and Suomussalmi Greenstone Belts

Name	*ID no.*	*Page*	*Major host rock(s)*	*Status*
Aittoranta	135	40	Mafic metavolcanic rock	Prospect
Jousijärvi	16	41	Mafic to felsic metavolcanic rocks	Prospect
Lokkiluoto	14	42	Mafic metatuff(ite)	Prospect
Moukkori (Housuvaara 1)	17	43	Uralite-porphyrite	Prospect
Mujesuo	134	45	Mafic metavolcanic rock	Prospect
Pahkalampi	60	46	Amphibolite, uralite-porphyrite and intermediate schist	Prospect
Palovaara	137	47	BIF	Prospect
Sepponen	63	48	Amphibolite	Prospect
Syrjälä	136	49	Mafic to intermediate metavolcanic rocks	Prospect

Miscellaneous deposits in northern Finland

Name	*ID no.*	*Page*	*Major host rock(s)*	*Status*
Mäkärärova (Siikalehto-1)	106	50	Granitoid gneiss	Prospect

Proterozoic

Lapland Domain

Central Lapland Greenstone Belt

Name	*ID no.*	*Page*	*Major host rock(s)*	*Status*
Ahvenjärvi (Isomaa)	132	52	Quartzite	Prospect
Hirvasselkä	110	53	Intermediate metavolcanic rock	Prospect
Hirvilavanmaa	116	54	Metakomatiite	Prospect
Hookana	105	56	Dolerite	Prospect
Kaaresselkä	103	57	Intermediate tuff and/or metasedimentary rock	Prospect
Kittilän Hanhilampi (Jolhikko)	126	58	Metadolerite	Prospect
Koppelokangas (Rimpelä)	109	59	Metasedimentary rocks	Prospect
Kuotko (Iso-Kuotko)	113	60	Mafic pyroclastic(?), Fe-tholeiitic rocks	Prospect
Kutuvuoma	133	62	Metakomatiite	Prospect
Lälleävuoma	119	63	Metakomatiite	Prospect
Lammasvuoma	117	64	"Albite fels" = metakomatiite?	Prospect
Loukinen	131	65	Metakomatiite	Prospect
Muusanlammit	128	67	Graphitic phyllite and tuffite	Prospect
Pahkavaara	139	69	Arkosic gneiss or greywacke gneiss	Prospect
Pahtavaara	102	70	Al-depleted(?) komatiites	Mine, active
Palokiimanselkä	107	73	Hornblende gneiss, albite-epidote-quartz and quartz-sericite rock	Prospect
Palovaara (Jerusaleminjänkä)	125	74	Metasedimentary rocks	Prospect
Pikku-Mustavaara	118	76	Graphitic phyllite	Prospect
Rovaselkä	123	78	Sulphide-rich schists	Prospect
Ruoppapalo	124	79	Intermediate dykes ("albitites")	Prospect
Saattopora	111	80	Intermediate metasedimentary and pyroclastic rocks	Mine, closed
Sirkka kaivos	121	82	Mafic lavas, tuffs and tuffites	Prospect
Sirkka W	122	84	Metasedimentary(?) rocks	Prospect

Table 1. Continued.

Central Lapland Greenstone Belt, continued

Name	*ID no.*	*Page*	*Major host rock(s)*	*Status*
Soretialehto	114	85	Metakomatiite	Prospect
Soretiavuoma N	115	87	Metakomatiite	Prospect
Sukseton	120	89	Felsic or intermediate metapyroclastic rock	Prospect
Suurikuusikko	112	90	Graphitic phyllite and/or -tuffite	Prospect
Tuongankuusikko	127	92	Graphitic phyllite	Prospect

Kuusamo Schist Belt

Name	*ID no.*	*Page*	*Major host rock(s)*	*Status*
Apajalahti	79	93	Sericite quartzite or garnet-antophyllite gneiss	Prospect
Hangaslampi	93	95	Metasedimentary or metavolcanic rock	Prospect
Hangaspuro (Juomasuo II)	96	97	Metasedimentary rock(s)	Prospect
Honkilehto	84	99	Sericite quartzite	Prospect
Iso-Rehvi	88	101	Metasedimentary(?) rocks	Prospect
Isoaho 1	100	103	Sericite quartzite	Prospect
Isoaho 2	101	105	Sericite quartzite	Prospect
Juomasuo	94	107	Mafic metavolcanic rocks	Pilot mine
Kantolahti	99	110	Mafic to intermediate tuffite	Prospect
Konttiaho	85	112	Sericite quartzite and albitised tuffite	Prospect
Kouvervaara	78	114	“Garnet schist” (sericite quartzite precursor)	Prospect
Kuusamon Hanhilampi	90	116	Sericite quartzite	Prospect
Lavasuo	97	118	?	Prospect
Lemmonlampi	80	119	Dolerite, mica schist	Prospect
Likalampi	98	121	?	Prospect
Meurastuksenaho	87	122	Sericite quartzite and metasiltstone	Prospect
Murronmaa	83	124	Metasedimentary rock = conglomerate(?)	Prospect
Ollinsuo	81	125	Metasedimentary sericite schist	Prospect
Pohjaslampi	91	127	Intermediate volcanogenic metasedimentary rock	Prospect
Pohjasvaara	92	129	Mafic metavolcanic rock	Prospect
Sakarinkaivulamminsuo (Juomasuo II)	95	131	Sericite quartzite	Prospect
Sarkanniemi	89	133	Metasedimentary rocks	Prospect
Säynäjävaara	82	135	Mafic metavolcanic rock	Prospect
Sivakkaharju	86	137	Sericite schist and albitised metasedimentary rocks	Prospect

Peräpohja Schist Belt

Name	*ID no.*	*Page*	*Major host rock(s)*	*Status*
Kivimaa	72	139	Dolerite sill (“albite diabase”)	Mine, closed
Petäjävaara (Rosvohotu)	74	141	Differentiated dolerite	Prospect
Sivakkajoki	73	142	Dolerite sill	Prospect
Vinsa	71	144	Dolerite (“albite diabase”)	Prospect

Svecofennian Domain

Raahe-Haapajärvi area

Name	*ID no.*	*Page*	*Major host rock(s)*	*Status*
Ahveroinen	38	146	Quartz-diorite	Prospect
Ängeslampi	28	147	Plagioclase porphyry	Prospect
Ängesneva (Kiimala 1)	26	149	Hypabyssal gabbro	Prospect
Antikanperä	25	151	Mica schist	Prospect
Antinoja	35	152	Mafic metalava or intermediate metavolcanic rock	Prospect
Hietajärvi	77	153	Plagioclase-hornblende porphyry (intermediate metavolcanic rock?)	Prospect
Kangaskylä (Tiaiskurunkangas)	37	154	Mafic metalava	Prospect
Käpykorpi	23	156	Tonalite	Prospect
Kiimala (Kiimala 2)	76	157	Hypabyssal gabbro	Prospect
Laivakangas-N	21	159	Quartz diorite and mafic metavolcanic rock	Prospect
Laivakangas-S	22	161	Massive intermediate metavolcanic rock	Prospect
Louetjärvi-Kukko	34	162	Intermediate metatuffite	Prospect
Oltava	24	163	Mica schist	Prospect
Pöhlölä	29	164	Quartz diorite to tonalite	Prospect
Sarjankylä	30	166	Plagioclase porphyry, diorite	Prospect
Sipilä	32	167	Mafic metalava	Prospect
Vesiperä	27	168	Hypabyssal gabbro	Prospect

Table 1. Continued.

Southern Ostrobothnia area

Name	*ID no.*	*Page*	*Major host rock(s)*	*Status*
Haasiakangas	39	170	?	Prospect
Kalliosalo (Kallionsalo)	56	171	Plagioclase porphyrite	Prospect
Marttalanniemi	42	173	Dacitic plagioclase porphyry	Prospect
Sudenkylä (Haudankylä)	57	175	Mafic metavolcanic rock or mica gneiss	Prospect
Suolasalmenneva	40	176	Metasedimentary and metavolcanic rocks	Prospect
Tervasmäki	64	177	Plagioclase porphyry, mica schist	Prospect
Timanttimaa	41	178	Dacitic plagioclase porphyry	Prospect
Tulisilmä (Sikakangas)	61	179	Plagioclase porphyry	Prospect
Ylijoki (Kivenneva)	43	180	Mica gneiss	Prospect

Savo area

Name	*ID no.*	*Page*	*Major host rock(s)*	*Status*
Hakojärvi	62	181	Intermediate. and felsic volcanogenic metasedimentary rocks	Prospect
Osikonmäki (Osikko)	45	182	Tonalite	Prospect
Pirilä	47	185	Intermediate metavolcanic or volcanogenic metasedimentary rock (mica gneiss)	Prospect
Pirilä II	46	187	Intermediate metavolcanic rock	Prospect

Tampere Schist Belt and Vammala Migmatite Zone

Name	*ID no.*	*Page*	*Major host rock(s)*	*Status*
Haveri	51	189	Felsic(?) metavolcanic rocks or tholeiitic metabasalts	Mine: closed; prospect: active
Hopeavuori	58	192	Intermediate metavolcanic rock and granodiorite	Prospect
Isovesi	50	193	Intermediate volcanogenic metasedimentary rock	Prospect
Jokisivu (Kujankallio)	49	195	Mafic metavolcanic rock, gabbro-diorite or andesitic porphyry	Prospect
Kaapelinkulma	53	197	Quartz diorite	Prospect
Kivikesku (Koukkujärvi)	59	199	Metagreywacke	Prospect
Tammijärvi	68	201	Metagreywacke	Prospect
Vatanen	52	202	Granodiorite (to diorite)	Prospect

Deposits in other areas in southern Finland

Name	*ID no.*	*Page*	*Major host rock(s)*	*Status*
Liesjärvi	69	203	Granodiorite	Prospect
Mäkrä	44	204	Intermediate metavolcanic rock	Prospect
Pääjärvi	67	205	Mica schist	Prospect
Satulinmäki	48	206	Aplite dykes	Prospect
Vatsa	104	207	?	Prospect

Metamorphosed epithermal

Proterozoic

Tampere Schist Belt

Name	*ID no.*	*Page*	*Major host rock(s)*	*Status*
Järvenpää	54	208	Intermediate metavolcanic rock(s)	Prospect
Kutemajärvi	55	210	Intermediate metatuff or tuffite	Mine, active

Skarn- or epigenetic ironstone-hosted

Proterozoic

Central Lapland Greenstone Belt

Name	*ID no.*	*Page*	*Major host rock(s)*	*Status*
Kuervitikko	130	213	Magnetite skarn or ironstone	Prospect

Peräpohja Schist Belt

Name	*ID no.*	*Page*	*Major host rock(s)*	*Status*
Vähäjoki	75	214	Magnetite skarn or ironstone	Prospect

Table 1. Continued.

Granitoid-related (non-skarn)

Proterozoic

Raahe-Haapajärvi area

Name	*ID no.*	*Page*	*Major host rock(s)*	*Status*
Jouhineva (Pöllä)*	33	216	Mafic and intermediate metavolcanic rocks(?)	Prospect
Kopsa*	36	217	Tonalite	Prospect
Kurula**	31	219	Mafic metavolcanic rock	Prospect

* Possibly, a porphyry-like base-metal mineralisation overprinted by mesothermal gold mineralisation

** Possibly, a granitoid-related (non-skarn) mineralisation overprinted by mesothermal lode-gold mineralisation

Deposits in other areas in southern Finland

Name	*ID no.*	*Page*	*Major host rock(s)*	*Status*
Ritovuori (Sarvilampi)*	70	220	Mafic, intermediate and felsic metavolcanic rocks	Prospect

* Possibly, a granitoid-related (non-skarn) mineralisation overprinted by mesothermal lode-gold mineralisation

Palaeoplacer

Proterozoic

Central Lapland Greenstone Belt

Name	*ID no.*	*Page*	*Major host rock(s)*	*Status*
Kaarestunturi	108	222	Conglomerate	Prospect
Outapää	129	224	Conglomerate	Prospect

ACKNOWLEDGEMENTS

Excellent co-operation between the University of Turku (UTU) and the Geological Survey of Finland (GTK) has been essential during this study. Their representatives in the project management, Prof. Pekka Nurmi and Dr. Raimo Lahtinen (GTK) and Prof. Heikki Papunen (UTU) are thanked for the success of the project. Also important and significant has been the co-operation with the Ministry of Trade and Industry, especially with the Chief Inspector of Mines, Dr Heikki Vartiainen.

A large number of people, which all cannot be listed here, have assisted during the progress of the project. Dr. Ritva Karhunen (GTK) has done the enormous job of scanning nearly all the figures and rewriting most of the figure captions. Dr. Hugh O'Brien's critical review of this report was significant and is thanked. A special acknowledgement must be given to all exploration and mining geologists who assisted during field visits and provided information on the deposits. Most of these people are mentioned in the reference lists of the respective deposits in the database (App. 2) by their 'personal communication' references.

Essential has also been the positive attitude towards the project among all exploration and mining companies active in Finland, especially, by Endomines Oy, Glenmore Highlands Ltd, Outokumpu Oyj, SES Finland Oy and Terra Mining Oy, named in alphabetical order.

REFERENCES

Anonymous 1984. Gold in Saskatchewan. Saskatchewan Geological Survey. Open File Report 84-1. 134 p.

Berger, B. R. & Bagby, W. C. 1991. The geology and origin of Carlin-type gold deposits. In: R. P. Foster (ed.) Gold Metallogeny and Exploration. Glasgow: Blackie, 210-248.

Colvine, A. C. 1989. An empirical model for the formation of Archean gold deposits: products of final cratonization of the Superior Province, Canada. In: R. R. Keays, W. R. H. Ramsay & D. I. Groves (eds) The Geology of Gold Deposits: The Perspective in 1988. Economic Geology Monograph 6, 37-53.

Colvine, A. C., Fyon, J. A., Heather, K. B., Marmont, S., Smith, P. M. & Troop, D. G. 1988. Archean lode gold deposits in Ontario, Canada. Ontario Geological Survey Miscellaneous Paper 139. 136 p.

Davidson, G. J. 1998. Variation in copper-gold styles through time in the Proterozoic Cloncurry goldfield, Mt Isa Inlier: a reconnaissance view. Australian Journal of Earth Sciences 45, 445-462.

Ferenczi, P. A. & Ahmad, M. 1998. Geology and mineral deposits of the Granites-Tanami and Tennant Creek Inliers, Northern Territory. AGSO Journal of Australian Geology & Geophysics 17, 19-33.

Gaal, G. & Sundblad, K. 1990. Metallogeny of gold in the Fennoscandian Shield. In: Gold '89 in Europe. Mineralium Deposita. 25, S104-S114.

Gebre-Mariam, M., Hagemann, S. G. & Groves, D. I. 1995. A classification for epigenetic Archaean lode-gold deposits. Mineralium Deposita 30, 408-410.

Goldfarb, R. J., Phillips, G. N. & Nockleberg, W. J. 1998. Tectonic setting of synorogenic gold deposits of the Pacific Rim. Ore Geology Reviews 13, 185-218.

Groves, D. I., Goldfarb, R. J., Gebre-Mariam, M., Hagemann, S. & Robert, F. 1998. Orogenic gold deposits: A proposed classification in the context of their crustal distribution and relationship to other gold deposit types. Ore Geology Reviews 13, 1-28.

Hedenquist, J. W., Izawa, E., Arribas, A. & White, N. C. 1996. Epithermal gold deposits: Styles, characteristics, and exploration. Resource Geology Special Publication 1. 16 p.

Kontas, E. 1981. Rabid determination of gold by flameless atom absorption spectrometry in the ppb and ppm ranges without organic solvent extraction. Atomic Spectroscopy 2, 59-61.

Kontoniemi, O. & Nurmi, P. A. (eds) 1998. Geological setting and characteristics of the tonalite-hosted Palaeoproterozoic gold deposit at Osikonmäki, Rantasalmi, southeastern Finland. Geological Survey of Finland, Special Paper 25. 119 p.

Korkiakoski, E. 1992. Geology and geochemistry of the metakomatiite-hosted Pahtavaara gold deposit in Sodankylä, northern Finland, with emphasis on hydrothermal alteration. Geological Survey of Finland, Bulletin 360. 96 p.

Lefebure, D. V. & Ray, G. E 1995. Selected British Columbia mineral deposit profiles. Vol. 1. British Columbia Ministry of Energy, Mines and Petroleum Resources, Open File 1995-20. 136 p.

Mäkelä, K. 1980. Geochemistry and origin of Haveri and Kiipu, Proterozoic strata-bound volcanogenic gold-copper and zinc mineralizations from southwestern Finland. Geological Survey of Finland, Bulletin 310. 79 p.

McCuaig, T. C. & Kerrich, R. 1998. P-T-t-deformation-fluid characteristics of lode gold deposits: evidence from alteration systematics. Ore Geology Reviews 12, 381-454.

Niskavaara, H. & Kontas, E. 1990. Reductive coprecipitation as a separation method for the determination of gold, palladium, platinum, rhodium, silver, selenium and tellurium in geological samples by graphite furnace atomic absorption spectrometry. Analytica Chemica Acta, 231, 273-282.

Nurmi, P. 1991. Geological setting, history of discovery and exploration economics of Precambrian gold occurrences in Finland. Journal of Geochemical Exploration 39, 273-287.

Nurmi, P. 1993. Archean Au in Finland. Overlooked Fennoscandian Shield has potential. Engineering and Mining Journal, November 1993, 32-36.

Nurmi, P., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.

Nurmi, P. & Sorjonen-Ward, P. (eds) 1993. Geological development, gold mineralization and exploration methods in the late Archaean Hattu schist belt, Ilomantsi, eastern Finland. Geological Survey of Finland, Special Paper 17. 386 p.

Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.

Puustinen, K. 1991. Gold deposits of Finland. Journal of Geochemical Exploration 39, 255-272.

Richardson D. J. & Ostry, G. 1996. Gold deposits of Manitoba. Manitoba Energy and Mines, Economic Geology Report ER86-1. 2nd edition. 114 p.

Rouhunkoski, P. & Isokangas, P. 1974. The copper-gold vein deposit of Kivimaa at Tervola, N-Finland. Bulletin of the Geological Society of Finland 46, 29-35.

Sillitoe, R. H. 1991. Intrusion-related gold deposits. In: R. P. Foster (ed.) Gold Metallurgy and Exploration. Glasgow: Blackie, 165-209.

Sorjonen-Ward, P. & Nurmi, P.A. 1997. An overview of the tectonic setting and characteristics of gold mineralization in Finland. In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 309-312.

VanderHor, F. & Groves, D. I. 1998. Systematic documentation of Archaean Gold Deposits of the Yilgarn Block. Minerals and Energy Research Institute of Western Australia, Project M195. Department of Geology and Geophysics, University of Western Australia. Perth. 52 p.

Appendix 1. Structure of a case description in the data base

FIELD	DESCRIPTION
Deposit name	*Present name (alternative names in brackets)*
Genetic type	*Genetic type of gold mineralisation*
Updated	*Date when updated (not shown in App. 2 where all data is as updated on 31/12/98)*
Location	
Geological domain	*Major geological domain, either Archaean, Proterozoic Lapland or Proterozoic Svecofennian*
Belt	*Smaller geological unit, e.g. Ilomantsi greenstone belt*
Map sheet	*Finnish base map sheet (1:20 000)*
Coordinates	*Finnish base map coordinates (x,y)*
Municipality	
Nearest town, access	*Distance to the nearest town, type of road(s) to or adjacent to the area, distance to the nearest roads*
Mining	
Exploration licence no.	*Identification no. in the data bases of the Ministry of Trade and Industry*
Mining concession no.	*Identification no. in the data bases of the Ministry of Trade and Industry*
Present holder	*Company presently holding the deposit; if no present holder:"Open for acquisition"*
Previous holders	
Status of development	*Mining method (if mined),otherwise: Prospect*
When mined	
Resources	*Ore in million tonnes, with cut-off grade used in the resource estimate(s)*
Total production	*Ore in tonnes or gold in kg/tonnes*
Total in-situ gold	*In kg or tonnes*
Best sections	*Given as: xx metres at yy g/t Au*
Extent of mineralisation	*Extent of the mineralised area*
Lodes	*Names of lodes, their host rocks, mutual relationships, strike, dip, plunge*
Exploration	
Discovery	*First indications, the process which led to the discovery*
Exploration history	*Which methods used, who did the exploration and when*
Drilling	*How much drilled, which drilling methods, when drilled*
Elements analysed	*Which elements analysed, by which method*
Economic evaluations	*Feasibility study or other economic evaluations: by whom and when done*
Geophysical response	*Any indications of the mineralisation by any geophysical method*
Primary geochemical dispersion	*Dispersion in bedrock (= lithogeochemical anomalies)*
Secondary geochemical dispersion	*Dispersion (anomalies) in Quaternary deposits, soil, stream sediments, peat, etc.*
Exploration geologist(s) in charge	*Exploration geologist(s) in charge, organisation(s)*
Ore	
Siting of gold	*Texture and location of gold and gold-bearing minerals relative to other minerals*
Fineness	*Composition of gold grains*
Major opaque minerals	*Major sulphides, oxides*
Minor opaque minerals	*Accessory sulphides, oxides*
Gangue	*Silicates, carbonates, scheelite, etc.*
Ore composition	*Bulk ore composition*
Enriched elements	*Components enriched in ore and its immediate wallrocks*
Ore fluid	*Nature of ore fluid; fluid inclusion data: PT conditions, XCO_2, XCH_4, salinity*
Stable isotope data	*O, C, S isotopes in different minerals and in the ore fluid*
Pb isotope data	*Source and timing indications*
Geology	
Major host rocks	*Primary rock type(s)*
Minor host rocks	*Primary rock type(s)*
Geological setting	*Local geological setting of the ore and host rocks*
Intrusives	*Intrusives in the area or nearest to it and their relationship with the host rocks, alteration and mineralisation*
Metamorphism	
Metamorphic history	*Metamorphism and its relationship with deformation and mineralisation*
Metamorphic grade	*Metamorphic facies and PT conditions*
Metamorphic mineral assemblage	*Unaltered mineral assemblages in all rocks in the area*

Structural setting	
Structural style	*Brittle, ductile, brittle-ductile, or other*
Closest major shear zone	*The closest crustal-scale shear or fault zone; its orientation and relationship tothe mineralisation*
Controlling structure	*Nature and orientation of the structure hosting ore*
Deformation history	*Deformation episodes and their relationship tostructures controlling ore*
Ore fabric	*Nature of ore-related fabrics*
Veins	*Veins related and unrelated to gold in the area, style of veining*
Alteration	
General alteration	*General style of alteration within the mineralised domain*
Proximal alteration	*Mineral assemblage(s) in all host rocks*
Intermediate alteration	*Mineral assemblage(s) in all host rocks*
Distal alteration	*Mineral assemblage(s) in all host rocks*
Timing of mineralisation	*Radiogenic isotope data, relative timing from cross-cutting rock units, etc.*
Genetic model	*How formed*
Post-mineralisation modification(s)	*Overprinting metamorphism, deformation, effect of cross-cutting rock units, etc.*

Figures (linked to the main database, most of the figures are presented only on the CD-ROM and Internet versions of the data base), for example:
Location in Finland
Location in regional geological context
Plan and cross-section maps of the deposit
Photographs: mine, rocks, ore, structures, microtextures, ore mineralogy

References *All primary sources of data: publications, non-confidential reports and personal communications*

Appendix 2. The FINGOLD data base; as updated on 31/12/1998.

In the Appendix 2, prospects are sorted according to the following scheme (as in Table 1): genetic type, then according to geographical domain and then in alphabetical order, empty fields and the field 'Updated' are not included.

In the data fields, references are given by numbers in square brackets: for example, '[1]' indicates the reference no. 1 which is given in full the data field 'References' for each deposit.

Name	***Elinsuo***				
GENETIC TYPE	Orogenic 'mesothermal'.				
LOCATION					
Geological domain	Archaean	**Belt**	Ilomantsi		
Map sheet	4244 08	**X coordinate**	6969050	**Y coordinate**	4560800
Municipality	Ilomantsi				
Nearest town, access	30 km NE from Ilomantsi, 95 km NE from Joensuu. A sealed road 1 km from the area, a gravel road to the area.				
MINING					
Present holder	OPEN FOR ACQUISITION.				
Previous holders	Geological Survey of Finland (GTK).				
Status of development	Prospect.				
Best sections	2 m at 3.0 ppm Au [1, 2].				
Lodes	Lodes are N-NE trending, subvertical [2].				
EXPLORATION					
Discovery	By the GTK on 1989 [1,2].				
Exploration history	GTK (1987-) [1,2,3]: Detailed geochemical till sampling: sampling grid 250 x 250 m over the greenstone belt covering 400 km^2. Follow-up as till-bedrock interface geochemistry, samples collected across the Au anomaly along traverses 100 m apart with sampling distance 10-30 m. Low-altitude air- and ground-magnetic, slingram and IP survey. Bedrock mapping based on outcrops, geophysics, trenching and diamond drilling. Special studies on Quaternary geology, ore mineralogy and geochemistry, and petrogenesis.				
Drilling	GTK: (1987-1993) [1,2]: 3 diamond-drill holes, total 396 m.				
Elements analysed	Ag, Al, As, Au, B, Ba, Bi, Ca, Cd, Co, CO_2, Cr, Cu, Fe, K, LOI, Mg, Mo, Na, Nb, P, Pb, Rb, REE, S, Sb, Sc, Se, Si, Sr, Te, Ti, Th, U, V, W, Y, Zn, Zr [2,3]				
Geophysical response	[2]: No response on magnetic, slingram or IP methods. Magnetic and electric methods do show the structural features of the area, including those which control gold mineralisation.				
Primary dispersion	Au and Te show good correlation; Ag and Bi show moderate correlation with Au. No consistent chemical zoning found yet [2,3].				
Secondary dispersion	[2]: Regional Au, As and B till anomaly, local Au, Te and Bi anomaly. Au content within the till anomaly is from tens of ppb to >1 ppm. Best combination for defining exploration targets: Au + Te + Bi – better than Au alone.				
Exploration geologist(s) in charge	GTK: Matti Damsten.				
ORE					
Siting of gold	Dissemination in host rocks, veins and "tourmaline-quartz rock". Gold occurs intergrown with tellurides, in the host rocks also intergrown pyrite and in veins also as inclusions in pyrite [2].				
Fineness	89-92% Au, 6-7% Ag [2].				
Major opaques	Pyrrhotite, pyrite [2].				
Minor opaques	Gold, tellurobismuthinite, hessite, volynskite, arsenopyrite, chalcopyrite, pentlandite, rutile, ilmenite [2].				
Gangue	Quartz, albite, K feldspar, biotite, muscovite, garnet, calcite?, chlorite, scheelite, titanite, tourmaline [2,3].				
Enriched elements	Au + Te, Bi, As, Mo, Ag, B, S, CO_2 [2,3].				
Stable isotope data	[2]: $\delta^{18}O$ (SMOW): +10.0‰ (tourmaline); δD (SMOW): -97‰ (tourmaline).				
GEOLOGY					
Major host rocks	Mica schist [2]				
Minor host rocks	Felsic porphyry dikes [2].				
Geological setting	The mineralisation is in the central part of the Hattu Schist Belt. The mica schists intruded by felsic porphyry dikes [2].				
Intrusives	Felsic porphyry dikes, predate gold mineralisation [2].				
METAMORPHISM					
Metamorphic history	[2]: Progressive regional metamorphism on ca. 2750-2700 Ma, apparently peaked soon after gold mineralisation, at a temperature of about 550±50°C. Thermal peak was synchronous or outlasted deformation				
Metamorphic grade	Greenschist-amphibolite facies transition [2].				
STRUCTURAL SETTING					
Structural style	Dominantly ductile [2].				
Closest major shear	Korvilansuo-Muurinsuo Shear Zone system adjacent to the deposit [2].				
Controlling structure	Korvilansuo shear zone [2].				

Veins	Quartz-tourmaline veins. Tourmaline-quartz rock: vein-dominated material? [2].
ALTERATION	
General alteration	Formation of tourmaline, quartz, biotite, muscovite, albite, chlorite, K feldspar, epidote, rutile, titanite. Tourmalinisation of the metatuffite is the most prominent feature [2].
Proximal alteration	Tourmalinisation: tourmaline replaces biotite [2,3].
TIMING	[2]: Either pre-peak metamorphic and formed under greenschist-facies conditions, or syn-peak metamorphic. Minimum age 2708-2693 Ma (U-Pb of titanite and monazite indicating peak metamorphism).
GENETIC MODEL	[2]: Formed in a structurally favourable, the most competent lithological units in the area. Precipitation of gold by desulphidation of fluid and, possibly, by decomposition of Au-Te complexes of fluid due to cooling and/or changes in pH and fO_2. Probably, gold precipitated just below 500°C with sulphides. The formation of the present low-temperature Te and Bi minerals most probably took place as subsolidus reactions with cooling temperature. The combination of arsenopyrite and oxygen isotope thermometry, sphalerite geobarometry, with the dominance of pyrrhotite and calcite instated of pyrite and dolomite, respectively, suggests uppermost-greenschist facies or conditions transitional between breenschist and amphibolite facies for mineralisation: T = 450-500°C, p = 2-3 kbar.
Post-mineralisation modifications	[2]: Probably, an Archaean post-mineralisation metamorphic overprint at about 500±50°C with weak deformation and porphyroblast overgrowth. On ca. 1800 Ma, a Proterozoic regional metamorphic overprint which is shown by K-Ar and Rb-Sr ages of micas.
FIGURES	[2]: Regional geology map, regional till Au, As, B, Bi, Cu, Te and W maps, local surface geology, cross section, ore photomicrograph.

References

1. Nurmi, P. A. 1993. Archaean Au in Finland. Engineering and Mining Journal, Nov., 32-34.
2. Nurmi, P. A. & Sorjonen-Ward, P. (eds) 1993. Geological Development, Gold Mineralization and Exploration Methods in the Late Archaean Hattu Schist Belt, Ilomantsi, Eastern Finland. Geological Survey of Finland, Special Paper 17. 386 p.
3. Rasilainen, K. 1996. Alteration geochemistry of gold occurrences in the late Archean Hattu Schist Belt, Ilomantsi, Eastern Finland. Academic dissertation: synopsis and four research papers. Geological Survey of Finland.140 p.

Name	***Kelokorpi***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Archaean **Belt** Ilomantsi
Map sheet	4244 08 **X coordinate** 6962700 **Y coordinate** 4562100
Municipality	Ilomantsi
Nearest town, access	25 km NE from Ilomantsi, 90 km NE from Joensuu. A sealed road 6 km from the area, a gravel road to the area?
MINING	
Exploration licence no.	6357/2.
Present holder	Outokumpu Oyj.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	4 m at 3.5 ppm Au [2].
Lodes	N-NE striking, subvertical lodes consisting of dissemination and auriferous quartz veinlets [3].
EXPLORATION	
Discovery	By the GTK on 1987 [2,3].
Exploration history	GTK (1987-) [1,3,4]: Detailed geochemical till sampling: sampling grid 250 x 250 m over the greenstone belt covering 400 km^2. Follow-up as till-bedrock interface geochemistry, samples collected across the Au anomaly along traverses 100 m apart with sampling distance 10-30 m. Low-altitude air- and ground-magnetic, slingram and IP survey. Bedrock mapping based on outcrops, geophysics, trenching and drilling. Special studies on Quaternary geology, ore mineralogy and geochemistry, and petrogenesis.
Drilling	GTK: (1987-1993) [2]: 1 diamond-drill hole, total 150 m.
Elements analysed	Ag, Al, As, Au, B, Ba, Bi, Ca, Cd, Co, CO_2, Cr, Cu, Fe, K, LOI, Mg, Mo, Na, Nb, P, Pb, Rb, REE, S, Sb, Sc, Se, Si, Sr, Te, Ti, Th, U, V, W, Y, Zn, Zr [3,4,5].
Geophysical response	[3]: No response on magnetic, slingram or IP methods. Magnetic and electric methods do show the structural features of the area, including those which control gold mineralisation.
Primary dispersion	[3,4]: Au and Te show good correlation; Ag and Bi show moderate correlation with Au. No consistent chemical zoning found yet.
Secondary dispersion	[3]: Regional Au, As and B till anomaly, local Au, Te and Bi anomaly. Au content within the till anomaly is from tens of ppb to >1 ppm. Best combination for defining exploration targets: Au + Te + Bi – better than Au alone. A 0.5-1 km wide Au anomaly in till along the western-southwestern contact of the Kuittila tonalite.
Exploration geologist(s) in charge	GTK: Matti Damsten.
ORE	
Siting of gold	Disseminated in host rocks and in quartz veinlets. Gold is associated with pyrrhotite in the metatuffite, with pyrite in the tonalite and with molybdenite, tourmaline, arsenopyrite, tellurides and pyrrhotite in the quartz-tourmaline veins [1, 3].
Fineness	82% Au, 14% Ag (one anal. sample) [3].
Major opaques	Pyrite, pyrrhotite [1,3].
Minor opaques	Gold, hedleyite, altaite, tsumoite, bismuth, pentlandite, arsenopyrite, chalcopyrite, sphalerite, mackinawite, galena, molybdenite, ilmenite, rutile [1,3].
Gangue	Quartz, tourmaline, albite, biotite, muscovite, garnet, calcite, scheelite, titanite [3].
Ore composition	Diamond-drill core [5]: 2.9 ppm Au, 0.405 ppm Ag, 58 ppm As, 594 ppm B, 674 ppm Ba, 0.7 ppm Bi, 24 ppm Co, 48 ppm Cu, <5 ppb Hg, 16 ppm Mo, 148 ppm Ni, 4.0 ppm Pb, 130 ppm Rb, 5740 ppm S, 0.2 ppm Sb, 0.16 ppm Se, 135 ppm Sr, 0.320 ppm Te, 5.9 ppm Th, 2.4 ppm U, 200 ppm V, 3.0 ppm W, 214 ppm Zn; 63.3% SiO_2, 0.65% TiO_2, 15.0% Al_2O_3, 7.77% Fe_2O_3, 3.87% MgO, 1.48% CaO, 2.07% Na_2O, 2.73% K_2O, 0.085% P_2O_5, 2.08% LOI.
Enriched elements	Au + Bi, Te, Ag, Mo, As, W, Se, B, K, S, CO_2 (+ Cu, Pb, Zn in tonalite) [3,4].
Stable isotope data	[3]: $\delta^{18}O$ (SMOW): +10.3‰ (quartz).
GEOLOGY	
Major host rocks	Intermediate metatuffite [3].
Minor host rocks	Kuittila tonalite [3].
Geological setting	[3]: The mineralisation is in the central part of the Hattu Schist Belt, at metatuffite-tonalite contact and in the metatuffite, to the east from the Kuittila tonalite pluton. The intermediate metatuffite is intruded by felsic porphyry dikes and by theKuittila pluton.
Intrusives	Felsic porphyry dikes and the Kuittila tonalite pluton which all predate gold mineralisation [3].
METAMORPHISM	
Metamorphic history	[3]: Progressive regional metamorphism on ca. 2750-2700 Ma, apparently peaked soon after gold mineralisation, at a temperature of about 550±50°C. Thermal peak was synchronous or outlasted deformation.
Metamorphic grade	Greenschist-amphibolite facies transition [3].
Metamorphic mineral assemblage	Intermediate metatuffite: albite-quartz-biotite-muscovite ± calcite, chlorite, rutile, tourmaline, epidote, titanite, zircon [3].

STRUCTURAL SETTING

Structural style	Brittle-ductile, ductile-dominated [3].
Closest major shear	Korvilansuo Shear Zone adjacent to the deposit [3].
Controlling structure	The Kelokorpi shear zone [3].
Veins	Auriferous quartz veinlets [3].

ALTERATION

General alteration	Formation of quartz, biotite, muscovite, albite, chlorite, calcite, tourmaline and rutile by replacements of: plagioclase -> sericite + calcite; biotite -> chlorite; ilmenite -> rutile [3,4].
TIMING	[3]: Either pre-peak metamorphic and formed under greenschist-facies conditions, or syn-peak metamorphic. Minimum age 2708-2693 Ma (U-Pb of titanite and monazite indicating peak metamorphism).
GENETIC MODEL	[3]: Formed in a structurally favourable, the most competent lithological units in the area. Precipitation of gold by desulphidation of fluid and, possibly, by decomposition of Au-Te complexes of fluid due to cooling and/or changes in pH and fO_2. Probably, gold precipitated just below 500°C with sulphides. The formation of the present low-temperature Te and Bi minerals most probably took place as subsolidus reactions with cooling temperature. The combination of arsenopyrite and oxygen isotope thermometry, sphalerite geobarometry, with the dominance of pyrrhotite and calcite instated of pyrite and dolomite, respectively, suggests uppermost-greenschist facies or conditions transitional between greenschist and amphibolite facies for mineralisation: T = 450-500°C, p = 2-3 kbar.
Post-mineralisation modifications	
	[3]: Probably, an Archaean post-mineralisation metamorphic overprint at about 500±50°C with deformation and porphyroblast overgrowth. This also affected $\delta^{18}O$ values of minerals. On ca. 1800 Ma, a Proterozoic regional metamorphic overprint which is shown by K-Ar and Rb-Sr ages of micas.
FIGURES	[3]: Regional geology map, regional till Au, As, B, Bi, Cu, Te and W maps, cross section, orephotomicrograph. [1]: Ore photomicrographs.

References

1. Kojonen, K., Johansson, B. & Pakkanen, L. 1991. Kelokorven Au-malmiaiheen malmimineralogiaa ja petrografiaa. Geological Survey of Finland, unpublished report M19/4244/-91/2/42. 8 p. (in Finnish)
2. Nurmi, P. A. 1993. Archaean Au in Finland. Engineering and Mining Journal, Nov., 32-34.
3. Nurmi, P. A. & Sorjonen-Ward, P. (eds) 1993. Geological Development, Gold Mineralization and Exploration Methods in the Late Archaean Hattu Schist Belt, Ilomantsi, Eastern Finland. Geological Survey of Finland, Special Paper 17. 386 p.
4. Rasilainen, K. 1996. Alteration geochemistry of gold occurrences in the late Archean Hattu Schist Belt, Ilomantsi, Eastern Finland. Academic dissertation: synopsis and four research papers. Geological Survey of Finland.140 p.
5. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.

Name	***Kivisuo***				
GENETIC TYPE	Orogenic ‘mesothermal’.				
LOCATION					
Geological domain	Archaean	**Belt**	Ilomantsi		
Map sheet	4244 08	**X coordinate**	6968000	**Y coordinate**	4560800
Municipality	Ilomantsi				
Nearest town, access	30 km NE from Ilomantsi, 95 km NE from Joensuu. A sealed road 200 m from the area.				
MINING					
Present holder	OPEN FOR ACQUISITION.				
Previous holders	Geological Survey of Finland (GTK).				
Status of development	Prospect.				
Best sections	4.9 m at 4.0 ppm Au [1,2].				
Lodes	N-NE striking, subvertical lodes formed by dissemination and quartz-tourmaline veins [2].				
EXPLORATION					
Discovery	By the GTK on 1986: arsenopyrite-bearing outcrop samples assayed 4-8 ppm Au; these samples were from an exploration pit excavated into one of the peak areas of an Au anomaly in till [2].				
Exploration history	GTK (1989-) [1,2]: Detailed geochemical till sampling: sampling grid 250 x 250 m over the greenstone belt covering 400 km^2. Follow-up as till-bedrock interface geochemistry, samples collected across the Au anomaly along traverses 100 m apart with sampling distance 10-30 m. Low-altitude air- and ground-magnetic, slingram and IP survey. Bedrock mapping based on outcrops, geophysics, trenching and diamond drilling. Special studies on Quaternary geology, ore mineralogy and geochemistry, and petrogenesis.				
Drilling	GTK (-1993) [1,2]: 13 diamond-drill holes, total 1763 m.				
Elements analysed	Ag, Al, As, Au, B, Ba, Bi, Ca, Cd, Co, CO_2, Cr, Cu, Fe, K, LOI, Mg, Mo, Na, Nb, P, Pb, Rb, REE, S, Sb, Sc, Se, Si, Sr, Te, Ti, Th, U, V, W, Y, Zn, Zr [2,3].				
Geophysical response	No response on magnetic, slingram or IP methods. Magnetic and electric methods do show the structural features of the area, including those which control gold mineralisation [2].				
Primary dispersion	Au and Te show good correlation; Ag and Bi show moderate correlation with Au. No consistent chemical zoning found yet [2,3].				
Secondary dispersion	[2]: Regional Au, As and B till anomaly, local Au, Te and Bi anomaly. Au content within the till anomaly is from tens of ppb to >1 ppm. Best combination for defining exploration targets: Au + Te + Bi – better than Au alone. A 0.5-1 km wide Au anomaly in till along the western-southwestern contact of the Kuittila tonalite.				
Exploration geologist(s) in charge					
	GTK: Matti Damsten.				
ORE					
Siting of gold	Disseminated in host rocks and in quartz-tourmaline veins. Gold occurs intergrown with tellurides, arsenopyrite and pyrrhotite in silicate matrix and, in the mafic metavolcanic rocks, the tellurides and arsenopyrite are associated with sulphides and ilmenite [2].				
Fineness	86% Au, 12% Ag (one anal. sample) [2]				
Major opaques	Pyrite, pyrrhotite [2].				
Minor opaques	Gold, tsumite, hedleyite, bismuth, arsenopyrite, marcasite, pentlandite, mackinawite, chalcopyrite, sphalerite, molybdenite, rutile, ilmenite [2].				
Gangue	Quartz, albite, K feldspar, biotite, muscovite, calcite, siderite, scheelite, titanite, tourmaline [2,3].				
Enriched elements	Au + Te, Bi, W, Ag, As, B, S, CO_2 [2,3].				
Ore fluid	Fluid inclusions: max T = 270-350°C, salinity 6-12 wt.% NaCl eq. [2].				
Stable isotope data	[2]: $\delta^{18}O$ (SMOW): +10.57 – +13.56‰ (calcite), +8.6 – +11.8‰ (quartz), +5.8‰ (biotite), +11.8‰ (calcite), -2.1 – +4.1‰ (scheelite), +9.7 – +10.3‰ (tourmaline), +9.4‰ (actinolite), +2.9‰ (epidote); => T = 411-500°C; δD (SMOW): -140 – -114‰ (tourmaline), -110‰ (actinolite); $\delta^{13}C$ (PDB): -10.92 – -9.25‰ (calcite).				
GEOLOGY					
Major host rocks	Mica schist [2].				
Minor host rocks	Mafic metatuffite [2].				
Geological setting	The mineralisation is in the central part of the Hattu Schist Belt. The mica schists of volcano-sedimentary origin are interbedded with mafic metatuffites and intruded by felsic porphyry dikes [2].				
Intrusives	Felsic porphyry dikes [2].				
METAMORPHISM					
Metamorphic history	[2]: Progressive regional metamorphism on ca. 2750-2700 Ma, apparently peaked soon after gold mineralisation, at a temperature of about 550±50°C. Thermal peak was synchronous or outlasted deformation.				
Metamorphic grade	Greenschist-amphibolite facies transition [2].				
STRUCTURAL SETTING					
Structural style	Dominantly ductile [2].				
Closest major shear	Korvilansuo-Muurinsuo Shear Zone system adjacent to the deposit [2].				

Controlling structure Korvilansuo shear zone [2].

Veins Quartz-tourmaline veins [2].

ALTERATION

General alteration Formation of quartz, biotite, muscovite, albite, chlorite, K feldspar, hornblende, tourmaline, rutile, calcite, titanite [2].

TIMING [2]. Either pre-peak metamorphic and formed under greenschist-facies conditions, or syn-peak metamorphic. Minimum age 2708-2693 Ma (U-Pb of titanite and monazite indicating peak metamorphism). [4]: Re-Os gives 2780±8 Ma for molybdenite (pre-gold stuff), but pyrite gives 2607±47 Ma, "which is in accordance with the titanite and monazite ages for gold mineralisation".

GENETIC MODEL [2]: Formed in a structurally favourable, the most competent lithological units in the area. Precipitation of gold by desulphidation of fluid and, possibly, by decomposition of Au-Te complexes of fluid due to cooling and/or changes in pH and fO_2. Probably, gold precipitated just below 500°C with sulphides. The formation of the present low-temperature Te and Bi minerals most probably took place as subsolidus reactions with cooling temperature. The combination of arsenopyrite and oxygen isotope thermometry, sphalerite geobarometry, with the dominance of pyrrhotite and calcite instated of pyrite and dolomite, respectively, suggests uppermost-greenschist facies or conditions transitional between breenschist and amphibolite facies for mineralisation: T = 450-500°C, p = 2-3 kbar.

Post-mineralisation modifications

[2]: Probably, an Archaean post-mineralisation metamorphic overprint at about 500±50°C with deformation and porphyroblast overgrowth. This also affected $\delta^{18}O$ values of minerals. On ca. 1800 Ma, a Proterozoic regional metamorphic overprint which is shown by K-Ar and Rb-Sr ages of micas.

FIGURES [2]: Regional geology map, regional till Au, As, B, Bi, Cu, Te and W maps, local surface geology, ore photomicrograph.

References

1. Nurmi, P. A. 1993. Archaean Au in Finland. Engineering and Mining Journal, Nov., 32-34.
2. Nurmi, P. A. & Sorjonen-Ward, P. (eds) 1993. Geological Development, Gold Mineralization and Exploration Methods in the Late Archaean Hattu Schist Belt, Ilomantsi, Eastern Finland. Geological Survey of Finland, Special Paper 17. 386 p.
3. Rasilainen, K. 1996. Alteration geochemistry of gold occurrences in the late Archean Hattu Schist Belt, Ilomantsi, Eastern Finland. Academic dissertation: synopsis and four research papers. Geological Survey of Finland.140 p.
4. Stein, H., Morgan, J. W., Markey, R. J. & Hannah, J. L. 1998. An introduction to Re-Os. What's in it for the mineral industry? SEG Newsletter 32, 1-15.

Name	***Korpilampi***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Archaean **Belt** Ilomantsi
Map sheet	4333 08 **X coordinate** 6991800 **Y coordinate** 4562050
Municipality	Ilomantsi
Nearest town, access	40 km NE from Ilomantsi, 100 km NE from Joensuu. A sealed road across the area.
MINING	
Exploration licence no.	5402/1.
Present holder	Endomines Oy.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	2.4 m at 1.1 ppm Au [1,2].
Lodes	Gently dipping lodes: dissemination at contact with pegmatite dikes in a ductile shear zone [2,4].
EXPLORATION	
Discovery	By the GTK on 1988: Au assays of sulphidised and tourmalinised outcrop material from a road cut [2].
Exploration history	GTK (1987-) [1,2,3,5]: Detailed geochemical till sampling: sampling grid 250 x 250 m over the greenstone belt covering 400 km^2. Follow-up as till-bedrock interface geochemistry, samples collected across the Au anomaly along traverses 100 m apart with sampling distance 10-30 m. Low-altitude air- and ground-magnetic, slingram and IP survey. Bedrock mapping based on outcrops, geophysics, trenching and diamond drilling. Special studies on Quaternary geology, ore mineralogy and geochemistry, and petrogenesis. SIP investigations. Endomines Oy (1996-): RC drilling [4].
Drilling	GTK: (1987-1993) [1,2]: 2 diamond-drill holes, total 169 m.
Elements analysed	Ag, Al, As, Au, B, Ba, Bi, Ca, Cd, Co, CO_2, Cr, Cu, Fe, K, LOI, Mg, Mo, Na, Nb, P, Pb, Rb, REE, S, Sb, Sc, Se, Si, Sr, Te, Ti, Th, U, V, W, Y, Zn, Zr [2,3].
Geophysical response	[2]: No response on magnetic, slingram or IP methods. Magnetic and electric methods do show the structural features of the area, including those which control gold mineralisation.
Primary dispersion	[2,3]: Au and Te show good correlation; Ag and Bi show moderate correlation with Au. No consistent chemical zoning found yet.
Secondary dispersion	[2]: Regional Au, As and B till anomaly, local Au, Te and Bi anomaly. Au content within the till anomaly is from tens of ppb to >1 ppm. Best combination for defining exploration targets: Au + Te + Bi – better than Au alone.
Exploration geologist(s) in charge	Endomines Oy: Timo Lindborg; GTK: Matti Damsten.
ORE	
Siting of gold	Dissemination in the host rock at contact with pegmatite dikes [2].
Major opaques	Pyrrhotite, pyrite [2]
Minor opaques	Gold, bismuth, bismuthinite, arsenopyrite, chalcopyrite, galena, pentlandite, arsenopyrite, rutile [2].
Gangue	Quartz, tourmaline, albite, K feldspar, biotite, muscovite, garnet, calcite?, chlorite, scheelite, titanite [2].
Enriched elements	Au + Te, Bi, Se, B, K, Rb, S, CO_2 [2,3].
GEOLOGY	
Major host rocks	Intermediate schist (tuffite) [2,4].
Minor host rocks	Komatiitic metavolcanic rocks [2].
Geological setting	The mineralisation is in the central part of the Hattu Schist Belt. The komatiitic and intermediate metavolcanic rocks are intruded by pegmatite dikes, all lithological units show complicated folding and contain sulphide dissemination [2].
Intrusives	Pegmatites, predate gold mineralisation? [2].
METAMORPHISM	
Metamorphic history	[2]: Progressive regional metamorphism on ca. 2750-2700 Ma, apparently peaked soon after gold mineralisation, at a temperature of about 550±50°C. Thermal peak was synchronous or outlasteddeformation.
Metamorphic grade	Greenschist-amphibolite facies transition [2].
STRUCTURAL SETTING	
Structural style	Brittle-ductile, ductile-dominated [2].
Closest major shear	The Pampalo Shear Zone system adjacent to the deposit [2].
Controlling structure	Pampalo shear system [2].
ALTERATION	
General alteration	Formation of quartz, biotite, muscovite, albite, chlorite, K feldspar, epidote, rutile, tourmaline, garnet, titanite [2,3].
TIMING	[2]: Either pre-peak metamorphic and formed under greenschist-facies conditions, or syn-peak metamorphic. Minimum age 2708-2693 Ma (U-Pb of titanite and monazite indicating peak metamorphism).

GENETIC MODEL [2]: Formed in a structurally favourable, the most competent lithological units in the area. Precipitation of gold by desulphidation of fluid and, possibly, by decomposition of Au-Te complexes of fluid due to cooling and/or changes in pH and fO_2. Probably, gold precipitated just below 500°C with sulphides. The formation of the present low-temperature Te and Bi minerals most probably took place as subsolidus reactions with cooling temperature.

Post-mineralisation modifications

[2]: Probably, an Archaean post-mineralisation metamorphic overprint at about 500±50°C with deformation and porphyroblast overgrowth. This also affected $\delta^{18}O$ values of minerals. On ca. 1800 Ma, a Proterozoic regional metamorphic overprint which is shown by K-Ar and Rb-Sr ages of micas.

FIGURES [2]: Regional geology map, regional till Au, As, B, Bi, Cu, Te and W maps

References

1. Nurmi, P. A. 1993. Archaean Au in Finland. Engineering and Mining Journal, Nov., 32-34.
2. Nurmi, P. A. & Sorjonen-Ward, P. (eds) 1993. Geological Development, Gold Mineralization and Exploration Methods in the Late Archaean Hattu Schist Belt, Ilomantsi, Eastern Finland. Geological Survey of Finland, Special Paper 17. 386 p.
3. Rasilainen, K. 1996. Alteration geochemistry of gold occurrences in the late Archean Hattu Schist Belt, Ilomantsi, Eastern Finland. Academic dissertation: synopsis and four research papers. Geological Survey of Finland.140 p.
4. Lindborg, T. 1997. Personal communication 2/10/1997.
5. Vanhala, H. 1997. Laboratory and field studies of environmental and exploration applications of the spectral induced-polarization (SIP) method. Geological Survey of Finland. 104 p.

Name	***Korvilansuo***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Archaean **Belt** Ilomantsi
Map sheet	4244 08 **X coordinate** 6966600 **Y coordinate** 4560000
Municipality	Ilomantsi
Nearest town, access	30 km NE from Ilomantsi, 95 km NE from Joensuu. A sealed road 500 m from the area.
MINING	
Exploration licence no.	6357/1.
Present holder	Outokumpu Oyj.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	5.5 m at 2.7 ppm Au [3,4].
Lodes	The N-NE striking, subvertical lodes are formed by dissemination in the host rock and auriferous tourmaline-quartz veins [4].
EXPLORATION	
Discovery	By the GTK on 1986: arsenopyrite-bearing outcrop samples assayed 4-8 ppm Au. These samples were from an exploration pit excavated into one of the peak areas of a till anomaly [4].
Exploration history	GTK (1987-) [4]: Detailed geochemical till sampling: sampling grid 250 x 250 m over the greenstone belt covering 400 km^2. Follow-up as till-bedrock interface geochemistry, samples collected across the Au anomaly along traverses 100 m apart with sampling distance 10-30 m. Low-altitude air- and ground-magnetic, slingram and IP survey. Bedrock mapping based on outcrops, geophysics, trenching and diamond drilling. Special studies on Quaternary geology, ore mineralogy and geochemistry, and petrogenesis.
Drilling	GTK (-1993) [3,4]: 14 diamond-drill holes, total 2083 m in 50-100 m traverse intervals.
Elements analysed	Ag, Al, As, Au, B, Ba, Bi, Ca, Cd, Co, CO_2, Cr, Cu, Fe, K, LOI, Mg, Mo, Na, Nb, P, Pb, Rb, REE, S, Sb, Sc, Se, Si, Sr, Te, Ti, Th, U, V, W, Y, Zn, Zr [2,4].
Geophysical response	No response on magnetic, slingram or IP methods. Magnetic and electric methods do show the structural features of the area, including those which control gold mineralisation [4].
Primary dispersion	Au and Te show good correlation; Ag and Bi show moderate correlation with Au. No consistent chemical zoning found yet [4,5].
Secondary dispersion	[3]: Regional Au, As and B till anomaly, local Au, Te and Bi anomaly. Au content within the till anomaly is from tens of ppb to >1 ppm. Best combination for defining exploration targets: Au + Te + Bi – better than Au alone. A 0.5-1 km wide Au anomaly in till along the western-southwestern contact of the Kuittila tonalite.
Exploration geologist(s) in charge	GTK: Matti Damsten.
ORE	
Siting of gold	Dissemination in mica schist and in tourmaline-quartz veins. Gold is as inclusions in biotite, pyrrhotite, pyrite and arsenopyrite, free between silicate grains, intergrown with tellurides and rutile and as Au-Ag telluride petzite [1,4].
Fineness	78-96% Au, 4-17% Ag [4].
Major opaques	Pyrite, pyrrhotite [1,4].
Minor opaques	Gold, frohbergite, altaite, hessite, tellurobismuthinite, petzite, melonite, rucklidgeite, volynskite, bismuth, arsenopyrite, chalcopyrite, sphalerite, galena, molybdenite, cubanite, pentlandite, mackinawite, rutile, ilmenite [1,4].
Gangue	Quartz, tourmaline, albite, K feldspar, biotite, muscovite, garnet, calcite, chlorite, scheelite, titanite [1,4,5].
Ore composition	Diamond-drill core [2]: 6.25 ppm Au, 0.519 ppm Ag, 870 ppm As, 2270 ppm B, 689 ppm Ba, 3.9 ppm Bi, 31 ppm Co, 51 ppm Cu, 17 ppb Hg, 1.0 ppm Mo, 155 ppm Ni, 2.1 ppm Pb, 124 ppm Rb, 5640 ppm S, 19.4 ppm Sb, 0.14 ppm Se, 213 ppm Sr, 2.250 ppm Te, 5.2 ppm Th, 2.3 ppm U, 170 ppm V, 7.0 ppm W, 109 ppm Zn; 59.9% SiO_2, 0.76% TiO_2, 16.3% Al_2O_3, 8.56% Fe_2O_3, 4.02% MgO, 1.25% CaO, 1.38% Na_2O, 3.97% K_2O, 0.18% P_2O_5, 0.62% LOI.
Enriched elements	Au + Te, As, Bi, Ag, B, K, S, CO2 [4,5].
Stable isotope data	[4]: $\delta^{18}O$ (SMOW): +10.40 – +15.07‰ (calcite), +10.1 – +12.3‰ (quartz), +10.9‰ (calcite), +1.7 ‰ (scheelite), +10.5 ‰ (tourmaline), +8.2‰ (muscovite); => T = 411-473°C; δD (SMOW): -96 ‰ (tourmaline), -77 (muscovite), -96 ‰ (chlorite); $\delta^{13}C$ (PDB): -12.41 – -8.67 ‰ (calcite).
GEOLOGY	
Major host rocks	Mica schist [4].
Minor host rocks	Mafic metatuffite and dolerite(?) [4].
Geological setting	The mineralisation is in the central part of the Hattu Schist Belt. The mica schists of sedimentary and/or volcano-sedimentary origin are intruded by felsic porphyry, gabbroidic dikes and tonalite [4].
Intrusives	Felsic porphyry, gabbroidic dikes and tonalite which all predate gold mineralisation, are affected by gold mineralisation-related alteration [4].
METAMORPHISM	
Metamorphic history	[4]: Progressive regional metamorphism on ca. 2750-2700 Ma, apparently peaked soon after gold mineralisation,

	at a temperature of about 539-595±50°C (garnet-biotite thermometer). Thermal peak was synchronous or outlasted deformation.
Metamorphic grade	Greenschist-amphibolite facies transition [4].
Metamorphic mineral assemblage	Andalusite-chlorite-biotite-quartz-plagioclase-garnet(-staurolite) [4, 5].
STRUCTURAL SETTING	
Structural style	Brittle-ductile to ductile [4].
Closest major shear	Korvilansuo-Muurinsuo Shear Zone system adjacent to the deposit [4].
Controlling structure	Korvilansuo shear zone [4].
Veins	Auriferous tourmaline-quartz veins up to a few tens of centimetres wide in the host rocks [4].
ALTERATION	
General alteration	Formation of quartz, biotite, muscovite, albite, chlorite, tourmaline, rutile, calcite, garnet. Locally, intense tourmaline formation. The alteration envelope is several hundreds of metres wide [4,5].
Proximal alteration	Chlorite-sericite-biotite; destruction of andalusite [4,5].
TIMING	[4]: Either pre-peak metamorphic and formed under greenschist-facies conditions, or syn-peak metamorphic. Minimum age 2708-2693 Ma (U-Pb of titanite and monazite indicating peak metamorphism).
GENETIC MODEL	[4]: Formed in a structurally favourable, the most competent lithological units in the area. Precipitation of gold by desulphidation of fluid and, possibly, by decomposition of Au-Te complexes of fluid due to cooling and/or changes in pH and fO_2. Probably, gold precipitated just below 500°C with sulphides. The formation of the present low-temperature Te and Bi minerals most probably took place as subsolidus reactions with cooling temperature. The combination of arsenopyrite and oxygen isotope thermometry, sphalerite geobarometry, with the dominance of pyrrhotite and calcite instated of pyrite and dolomite, respectively, suggests uppermost-greenschist facies or conditions transitional between breenschist and amphibolite facies for mineralisation: T = 450-500°C, p = 2-3 kbar.
Post-mineralisation modifications	
	[4]: Probably, an Archaean post-mineralisation metamorphic overprint at about 500±50°C with deformation and porphyroblast overgrowth. This also affected $\delta^{18}O$ values of minerals. On ca. 1800 Ma, a Proterozoic regional metamorphic overprint which is shown by K-Ar and Rb-Sr ages of micas. Kyanite, probably a Proterozoic overprint, is replacing sericite formed during alteration.
FIGURES	[4]: Regional geology map, regional till Au, As, B, Bi, Cu, Te and W maps, local surface geology, orephotomicrographs. [1]: Ore photomicrographs.

References

1. Kojonen, K., Johansson, B., Pakkanen, L. & O´Brien, H. 1991. Ilomantsin Korvilansuon Au-malmiaiheen mineralogiaa ja petrografiaa. Geological Survey of Finland, unpublished report M19/4244/-91/1/42. 40 p. (in Finnish)
2. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
3. Nurmi, P. A. 1993. Archaean Au in Finland. Engineering and Mining Journal, Nov., 32-34.
4. Nurmi, P. A. & Sorjonen-Ward, P. (eds) 1993. Geological Development, Gold Mineralization and Exploration Methods in the Late Archaean Hattu Schist Belt, Ilomantsi, Eastern Finland. Geological Survey of Finland, Special Paper 17. 386 p.
5. Rasilainen, K. 1996. Alteration geochemistry of gold occurrences in the late Archean Hattu Schist Belt, Ilomantsi, Eastern Finland. Academic dissertation: synopsis and four research papers. Geological Survey of Finland.140 p.

Name	***Kuittila***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Archaean **Belt** Ilomantsi
Map sheet	4244 08 **X coordinate** 6963800 **Y coordinate** 4561400
Municipality	Ilomantsi
Nearest town, access	25 km NE from Ilomantsi, 90 km NE from Joensuu. A sealed road 5 km from the area, a gravel road 200 m from the area.
MINING	
Exploration licence no.	3808, 3956.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (1984-) (GTK).
Status of development	Prospect.
Resources	0.14 Mt 4 ppm Au or 0.275 Mt 2.58 ppm [1,3,4,5].
Total in-situ gold	573 or 709 kg Au [1,3,4,5].
Best sections	1 m at 19.4 ppm Au, 2 m at 10.4 ppm Au, 4 m at 4.5 ppm Au, 7 m at 2.1 ppm Au, 9 m at 1.4 ppm Au [9].
Lodes	The NW-SE trending, subvertical lode is formed by dissemination and a set of quartz veins within a shear zone in tonalite [5].
EXPLORATION	
Discovery	Discovered on 1984 by the GTK: during a follow-up survey to determine source for scheelite grains and W and Mo anomalies in till [1,5].
Exploration history	GTK [1,2,3,4,5,7,9]: Detailed geochemical till sampling: sampling grid 250 x 250 m over the greenstone belt covering 400 km^2. Follow-up as till-bedrock interface geochemistry, samples collected across the local W and Mo anomalies with sampling grid 50x50 m. Low-altitude air- and ground-magnetic, slingram and IP survey. Bedrock mapping based on outcrops, geophysics, trenching, diamond and percussion drilling. Special studies on Quaternary geology, silicate and opaque mineral mineralogy and geochemistry, and petrogenesis.
Drilling	GTK (-1993) [1,5]: 20 diamond-drill holes, total 2727 m.
Elements analysed	Ag, Al, As, Au, B, Ba, Bi, Ca, Cd, Co, CO_2, Cr, Cu, Fe, K, LOI, Mg, Mo, Na, Nb, P, Pb, Rb, REE, S, Sb, Sc, Se, Si, Sr, Te, Ti, Th, U, V, W, Y, Zn, Zr [1,5,6].
Geophysical response	No response on magnetic, slingram or IP methods. Magnetic and electric methods do show the structural features of the area, including those which control gold mineralisation [1,5].
Primary dispersion	[5]: Au and Te show a good mutual correlation; Ag and Bi show moderate correlation with Au. No consistent chemical zoning found yet. Lithogeochemical anomalies: Mo, W, CO_2, Cu, S, Rb, K, Si and LOI enrichment and Na and Sr depletion define anomalies for hundreds metres around the Au mineralisation.
Secondary dispersion	[5]: Regional Au, As and B till anomaly, local Au, Te and Bi anomalyin till. Au content within the till anomaly is from tens of ppb to >1 ppm. Best combination for defining exploration targets: Au + Te + Bi – better than Au alone. A 0.5-1 km wide Au anomaly in till along the western-southwestern contact of the Kuittila tonalite.
Exploration geologist(s) in charge	GTK: Matti Damsten.
ORE	
Siting of gold	Chiefly as inclusions or intergrowths with pyrite in association with tellurides, but also associated withgalena, pyrrhotite, quartz, muscovite and biotite [1,2,5,9].
Fineness	92% Au, 6% Ag [5].
Major opaques	Pyrrhotite, pyrite [1,2,5,9].
Minor opaques	Gold, electrum, silver, hessite, petzite, altaite, frohbergite, tellurobismuthinite, native tellurium, chalcopyrite, sphalerite, galena, pentlandite, arsenopyrite, cubanite, molybdenite, mackinawite, ilmenite, rutile [1,2,5,9].
Gangue	Quartz, albite, K feldspar, biotite, muscovite, garnet, calcite, chlorite, scheelite, titanite, tourmaline [1,2,5].
Ore composition	Diamond-drill core [5]: 3.5 ppm Au, 4.7 ppm Ag, 3.0 ppm As, 163 ppm B, 1020 ppm Ba, 1.2 ppm Bi, 17 ppm Co, 14 ppm Cu, 6.0 ppb Hg, 75 ppm Mo, 49 ppm Ni, 21 ppm Pb, 114 ppm Rb, 630 ppm S, 0.2 ppm Sb, 0.10 ppm Se, 485 ppm Sr, 2.1 ppm Te, 6.4 ppm Th, 2.9 ppm U, 90 ppm V, 23 ppm W, 55 ppm Zn; 68.9% SiO_2, 0.38% TiO_2, 13.3% Al_2O_3, 3.70% Fe_2O_3, 2.41% MgO, 2.69% CaO, 3.12% Na_2O, 3.27% K_2O, 0.13% P_2O_5, 1.16% LOI.
Enriched elements	Au + Bi, Fe_2O_3, Ag, Mo, Pb, As, W, B, K, Rb, S, CO_2 [5,6,9].
Ore fluid	Fluid inclusions: max T = 237-251C, salinity 7 wt.% NaCl eq. [5].
Stable isotope data	[5]: $\delta^{18}O$ (SMOW): +4.66 – +10.68 ‰ (calcite), +4.3 – +9.3 ‰ (quartz), +1.0 – +3.9 ‰ (biotite), +9.3 ‰ (calcite), +9.2 ‰ (albite); => T = 500°C; δD (SMOW): -60 – -47 ‰ (biotite); $\delta^{13}C$ (PDB): -9.71 – -7.17 ‰ (calcite).
Pb isotope data	Pb-Pb age for galena: 2700±75 Ma [5].
GEOLOGY	
Major host rocks	Tonalite [1,2,5,6].
Geological setting	The mineralisation is in the central part of the Hattu Schist Belt, in the sheared, quartz-sericite altered Kuittila tonalite near tonalite-mica schist contact, in the SW part of the intrusion [1,5,9].

Intrusives	[5]: The tonalite hosting the deposit predates all mineralisation. The tonalite is cross cut by a mafic dike which also predates both W-Mo- and Au-bearing quartz veins.
METAMORPHISM	
Metamorphic history	[5]: Progressive regional metamorphism on ca. 2750-2700 Ma, apparently peaked soon after gold mineralisation, at a temperature of about 550±50°C (according to biotite-garnet thermometry within the schist belt). Thermal peak was synchronous or outlasted deformation.
Metamorphic grade	Greenschist-amphibolite facies transition [5].
Metamorphic mineral assemblage	Plagioclase-quartz-biotite-muscovite(-tourmaline-garnet-apatite-zircon) [9].
STRUCTURAL SETTING	
Structural style	Ductile-dominated.
Closest major shear	Kelokorpi Shear Zone 1.3 km to the east of the deposit [5].
Controlling structure	A shear zone along contact between the tonalite intrusion and its wallrocks(?), sinistral sense of shear in the area of the deposit [5].
Veins	[5,9]: Two pre-gold, scheelite- and molybdenite-bearing quartz vein sets: two sets or a set of conjugate veins. These are followed by barren quartz veins. The latest set of quartz-tourmaline±calcite veins is gold-bearing, commonly laminated and may also show other features of repeated opening and sealing. The vein thickness varies from 0.5 cm to 40 cm [9].
ALTERATION	
General alteration	Pervasive alteration and ductile deformation are only related to the auriferous veins. Formation of the assemblage quartz-albite-muscovite-biotite-tourmaline-rutile-calcite-K feldspar-epidote: hydration, carbonation and K alteration [5].
Proximal alteration	Characterised by the assemblage quartz-muscovite-biotite-tourmaline-rutile-calcite [5,6,7].
Distal alteration	Albite-quartz-biotite-muscovite ± K feldspar, apatite, calcite [9].
TIMING	[5]: The U-Pb zircon age of the tonalite is 2745±11 Ma (max. age for mineralisation). Rb-Sr age of the tonalite, 2789±290 Ma, is poorly constrained. The mineralisation is either pre-peak metamorphic and formed under greenschist-facies conditions, or syn-peak metamorphic. Minimum age 2708-2693 Ma (U-Pb of titanite and monazite indicating peak metamorphism). Pb-Pb age for galena: 2700±75 Ma. [8]: Re-Os gives 2780±8 Ma for molybdenite (pre-gold stuff), but pyrite gives 2607±47 Ma, "which is in accordance with the titanite and monazite ages for gold mineralisation".
GENETIC MODEL	[5]: Formed in a structurally favourable, the most competent lithological units in the area. Precipitation of gold by desulphidation of fluid and, possibly, by decomposition of Au-Te complexes of fluid due to cooling and/or changes in pH and fO_2. Probably, gold precipitated just below 500°C with sulphides. The formation of the present low-temperature Te and Bi minerals most probably took place as subsolidus reactions with cooling temperature. The combination of arsenopyrite and oxygen isotope thermometry, sphalerite geobarometry, with the dominance of pyrrhotite and calcite instated of pyrite and dolomite, respectively, suggests uppermost-greenschist facies or conditions transitional between breenschist and amphibolite facies for mineralisation: T = 450-500°C, p = 2-3 kbar. The proximal alteration assemblage given in [9] also supports these PT-conditions for gold mineralisation.
Post-mineralisation modifications	
	[5]: Probably, an Archaean post-mineralisation metamorphic overprint at about 500±50°C with deformation and porphyroblast overgrowth. This also affected $\delta^{18}O$ values of minerals. On ca. 1800 Ma, a Proterozoic regional metamorphic overprint which is shown by K-Ar and Rb-Sr ages of micas.
FIGURES	[5]: Regional geology map, regional till Au, As, B, Bi, Cu, Te and W maps, local surface geology map,ore photomicrograph. [2]: Ore photomicrographs.

References

1. Damsten, M. 1990. Tutkimustyöselostus Ilomantsin kunnassa valtausalueilla Kuittila 1-3, kaiv. rek. no. 3808 ja 3956, suoritetuista tutkimuksista. Geological Survey of Finland, unpublished report M06/4244/-90/1/10. 8 p. (in Finnish)
2. Kojonen, K. & Johansson, B. 1989. Ilomantsin Kuittilan Au-malmiaiheen mineralogiaa ja petrografiaa. Geological Survey of Finland, unpublished report M19/4244/-89/1/42. 17 p. (in Finnish)
3. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
4. Nurmi, P. A. 1993. Archaean Au in Finland. Engineering and Mining Journal, Nov., 32-34.
5. Nurmi, P. A. & Sorjonen-Ward, P. (eds) 1993. Geological Development, Gold Mineralization and Exploration Methods in the Late Archaean Hattu Schist Belt, Ilomantsi, Eastern Finland. Geological Survey of Finland, Special Paper 17. 386 p.
6. Rasilainen, K. 1996. Alteration geochemistry of gold occurrences in the late Archean Hattu Schist Belt, Ilomantsi, Eastern Finland. Academic dissertation: synopsis and four research papers. Geological Survey of Finland.140 p.
7. Salminen, R. 1986. Au, W, Mo sekä eräät muut metallit maaperässä ja kallioperässä Kuittilassa Ilomantsissa. Geological Survey of Finland, unpublished report S/41/4244/1/1986. 8 p. (in Finnish)
8. Stein, H., Morgan, J. W., Markey, R. J. & Hannah, J. L. 1998. An introduction to Re-Os. What's in it for the mineral industry? SEG Newsletter 32, 1-15.
9. Ojanen, H. 1993. Ilomantsin Kuittilan ja Muurinsuon Au- ja Mo-W-mineralisaatioiden petrografia ja malmimineralogia. Unpublished MSc thesis. Department of Geology, University of Oulu. 108 p. (in Finnish)

Name	***Kuivisto***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Archaean **Belt** Ilomantsi
Map sheet	4333 **X coordinate** 6992900 **Y coordinate** 4560660
Municipality	Ilomantsi
Nearest town, access	40 km NE from Ilomantsi, 100 km NE from Joensuu. A sealed road 0.5 km from the area.
MINING	
Exploration licence no.	5210/1.
Present holder	Endomines Oy.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	12 m at 3.6 ppm Au.
EXPLORATION	
Exploration history	GTK [1]: low-altitude air- and ground-magnetic, slingram and IP survey. Detailed geochemical till sampling: sampling grid 250x250 m over the greenstone belt covering 400 km^2.
	Endomines: till geochemical survey, trenching.
Geophysical response	[1]: No response on magnetic, slingram or IP methods. Magnetic and electric methods do show the structural features of the area, including those which control gold mineralisation.
Secondary dispersion	[1]: Regional Au, As and B till anomaly, local Au, Te and Bi anomaly(?). Au content within the till anomaly is from tens of ppb to >1 ppm. Best combination for defining exploration targets: Au + Te + Bi - better than Au alone.
Exploration geologist(s) in charge	
	Endomines: Timo Lindborg.
GEOLOGY	
Major host rocks	Mica schist(?).
Geological setting	The mineralisation is in the northern part of the Hattu Schist Belt. The host rocks are intruded by pegmatite dikes, all lithological units show complicated folding [1].
METAMORPHISM	
Metamorphic history	[1]: Progressive regional metamorphism on ca. 2750-2700 Ma, apparently peaked soon after gold mineralisation, at a temperature of about 550±50°C. Thermal peak was synchronous or outlasted deformation.
Metamorphic grade	Greenschist-amphibolite facies transition [1].
STRUCTURAL SETTING	
Closest major shear	The Pampalo Shear Zone system? [1].
Deformation history	Rapid and extensive crustal generation and deformation between 2.76-2.73 Ma [1].
TIMING	[1]: Either pre-peak metamorphic and formed under greenschist-facies conditions, or syn-peak metamorphic. Minimum age 2708-2693 Ma (U-Pb of titanite and monazite indicating peak metamorphism in the schist belt).
GENETIC MODEL	[1]: Formed in a structurally favourable, the most competent lithological units in the area. Precipitationof gold by desulphidation of fluid and, possibly, by decomposition of Au-Te complexes of fluid due to cooling and/or changes in pH and fO2. Probably, gold precipitated just below 500°C with sulphides. The formation of the present low-temperature Te and Bi minerals most probably took place as subsolidus reactions with cooling temperature. Within the schist belt, the combination of arsenopyrite and oxygen isotope thermometry, sphalerite geobarometry, with the dominance of pyrrhotite and calcite instated of pyrite and dolomite, respectively, suggests uppermost-greenschist facies or conditions transitional between breenschist and amphibolite facies for mineralisation: T = 450-500°C, p = 2-3 kbar.
Post-mineralisation modifications	
	[1]: Probably, an Archaean post-mineralisation metamorphic overprint at about 500±50°C with deformation and porphyroblast overgrowth. On ca. 1800 Ma, a Proterozoic regional metamorphic overprint which is shown by K-Ar and Rb-Sr ages of micas within the schist belt.

References

1. Nurmi, P. A. & Sorjonen-Ward, P. (eds) 1993. Geological Development, Gold Mineralization and Exploration Methods in the Late Archaean Hattu Schist Belt, Ilomantsi, Eastern Finland. Geological Survey of Finland, Special Paper 17. 386 p.

Name	***Muurinsuo***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Archaean **Belt** Ilomantsi
Map sheet	4244 08 **X coordinate** 6970040 **Y coordinate** 4562900
Municipality	Ilomantsi
Nearest town, access	30 km NE from Ilomantsi, 95 km NE from Joensuu. A sealed road 500 m from the area, a gravel road to the area?
MINING	
Exploration licence no.	6540/1.
Present holder	Outokumpu Oyj.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	5 m at 4.9. ppm Au [1,3].
Extent of mineralisation	Width: 11 m [5].
Lodes	A set of N-NE striking, subvertical lodes which comprise dissemination in the host rocks [3].
EXPLORATION	
Discovery	By GTK on 1987 [5].
Exploration history	GTK (1987-) [3,4,5]: Detailed geochemical till sampling: sampling grid 250 x 250 m over the greenstone belt covering 400 km^2. Follow-up as till-bedrock interface geochemistry, samples collected across the Au anomaly along traverses 100 m apart with sampling distance 10-30 m. Low-altitude air- and ground-magnetic, slingram and IP survey. Bedrock mapping based on outcrops, geophysics, trenching and diamond drilling. Special studies on Quaternary geology, ore mineralogy and geochemistry, and petrogenesis.
Drilling	GTK (-1993) [1,3]: 21 diamond-drill holes, total 2048 m, drilling profile spacing: 50 m.
Elements analysed	Ag, Al, As, Au, B, Ba, Bi, Ca, Cd, Co, CO_2, Cr, Cu, Fe, K, LOI, Mg, Mo, Na, Nb, P, Pb, Rb, REE, S, Sb, Sc, Se, Si, Sr, Te, Ti, Th, U, V, W, Y, Zn, Zr [3].
Geophysical response	No response on magnetic, slingram or IP methods. Magnetic and electric methods do show the structural features of the area, including those which control gold mineralisation [3].
Primary dispersion	Au and Te show good correlation; Ag and Bi show moderate correlation with Au. No consistent chemical zoning found yet [3,4].
Secondary dispersion	[3]: Regional Au, As and B till anomaly, local Au, Te and Bi anomaly. Au content within the till anomaly is from tens of ppb to >1 ppm. Best combination for defining exploration targets: Au + Te + Bi – better than Au alone. A 0.5-1 km wide Au anomaly in till along the western-southwestern contact of the Kuittila tonalite.
Exploration geologist(s) in charge	GTK: Matti Damsten.
ORE	
Siting of gold	Dissemination in host rocks. Gold is intergrown with pyrrhotite, pyrite, arsenopyrite, gersdorffite and tellurides [3].
Fineness	83-97% Au, 4-15% Ag, 0.01-2.8% Sb [3,5].
Major opaques	Pyrrhotite, pyrite [3].
Minor opaques	Gold, electrum, tellurobismuthinite, tsumoite, altaite, hessite, petzite, volynskite, chalcopyrite, pentlandite, galena, arsenopyrite, gersdorffite, molybdenite, cubanite, mackinawite, ilmenite, rutile [3].
Gangue	Quartz, albite, K feldspar, biotite, muscovite, garnet, calcite, siderite, scheelite, titanite, tourmaline [3].
Ore composition	Diamond-drill core [3]: 2.6 ppm Au, 0.152 ppm Ag, 18.0 ppm As, 410 ppm B, 593 ppm Ba, 1.4 ppm Bi, 27 ppm Co, 55 ppm Cu, <5 ppb Hg, 4 ppm Mo, 139 ppm Ni, <2 ppm Pb, 94 ppm Rb, 7470 ppm S, <0.2 ppm Sb, 0.18 ppm Se, 285 ppm Sr, 1.02 ppm Te, 7.0 ppm Th, 2.4 ppm U, 200 ppm V, 3.0 ppm W, 120 ppm Zn; 59.0% SiO_2, 0.89% TiO_2, 18.4% Al_2O_3, 7.77% Fe_2O_3, 3.50% MgO, 1.40% CaO, 1.88% Na_2O, 2.64% K_2O, 0.15% P_2O_5, 3.25% LOI.
Enriched elements	Au + Te, Bi, As, Ag, Cu, B, K, Rb, S, CO_2 [3,4,5].
Stable isotope data	[3]: $\delta^{18}O$ (SMOW): +10.8 – +11.4‰ (quartz), -6.6 – +8.6‰ (biotite), -0.6‰ (epidote), +10.3 – +10.7‰ (albite); => T = 400-580°C; δD (SMOW): -67 – -55‰ (biotite), -88‰ (actinolite).
GEOLOGY	
Major host rocks	Mica schist (volcanogenic metasedimentary rock) [2,3,4,5].
Minor host rocks	Mafic or ultramafic schist, mafic dykes, felsic porphyries [2,3,4,5].
Geological setting	The mineralisation is in the central part of the Hattu Schist Belt. The mica schist units are interbedded with mafic metatuffites and dikes, and intruded by felsic porphyry; the mineralisation is in the NW hangingwall of the Kuittila tonalite [3,5].
Intrusives	The late-orogenic Kuittila tonalite, felsic porphyries and mafic dikes predate gold mineralisation [3].
METAMORPHISM	
Metamorphic history	[3]: Progressive regional metamorphism on ca. 2750-2700 Ma, apparently peaked soon after gold mineralisation, at a temperature of about 550±50°C (garnet-biotite thermometer). Thermal peak was synchronous or outlasted deformation.
Metamorphic grade	Greenschist-amphibolite facies transition [3].

Metamorphic mineral assemblage Mica schists: andesine-quartz-biotite-muscovite-chlorite(-tourmaline-garnet-apatite-zircon) [3,5].
Mafic or ultramafic schist: hornblende-biotite(-tourmaline-calcite-opaques) [5].

STRUCTURAL SETTING

Structural style Brittle-ductile to ductile [3].

Closest major shear Korvilansuo-Muurinsuo Shear Zone system adjacent to the deposit [3].

Controlling structure Korvilansuo shear zone, dominantly ductile [3].

Veins Quartz-calcite and quartz-siderite veins commonly occur in the felsic porphyries and contain arsenopyrite and tellurides. Auriferous quartz-tourmaline veins in the main host rock [3,5].

ALTERATION

General alteration Formation of the assemblage quartz-albite-muscovite-chlorite-tourmaline-calcite-rutile-K feldspar-epidote-hornblende-titanite-siderite-garnet [3,4].

TIMING [3]: Either pre-peak metamorphic and formed under greenschist-facies conditions, or syn-peak metamorphic. Minimum age 2708-2693 Ma (U-Pb of titanite and monazite indicating peak metamorphism).

GENETIC MODEL [3]: Formed in a structurally favourable, the most competent lithological units in the area. Precipitation of gold by desulphidation of fluid and, possibly, by decomposition of Au-Te complexes of fluid due to cooling and/or changes in pH and fO_2. Probably, gold precipitated just below 500°C with sulphides. The formation of the present low-temperature Te and Bi minerals most probably took place as subsolidus reactions with cooling temperature. The combination of arsenopyrite and oxygen isotope thermometry, sphalerite geobarometry, with the dominance of pyrrhotite and calcite instated of pyrite and dolomite, respectively, suggests uppermost-greenschist facies or conditions transitional between breenschist and amphibolite facies for mineralisation: T = 450-500°C, p = 2-3 kbar.

Post-mineralisation modifications

[3]: Probably, an Archaean post-mineralisation metamorphic overprint at about 500±50°C with deformation and porphyroblast overgrowth. This also affected $\delta^{18}O$ values of minerals. On ca. 1800 Ma, a Proterozoic regional metamorphic overprint which is shown by K-Ar and Rb-Sr ages of micas.

FIGURES [3]: Regional geology map, regional till Au, As, B, Bi, Cu, Te and W maps, local surface geology map ,ore photomicrograph.
[5]: Several outcrop and thin section photographs.

References

1. Nurmi, P. A. 1993. Archaean Au in Finland. Engineering and Mining Journal, Nov., 32-34.
2. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
3. Nurmi, P. A. & Sorjonen-Ward, P. (eds) 1993. Geological Development, Gold Mineralization and Exploration Methods in the Late Archaean Hattu Schist Belt, Ilomantsi, Eastern Finland. Geological Survey of Finland, Special Paper 17. 386 p.
4. Rasilainen, K. 1996. Alteration geochemistry of gold occurrences in the late Archean Hattu Schist Belt, Ilomantsi, Eastern Finland. Academic dissertation: synopsis and four research papers. Geological Survey of Finland.140 p.
5. Ojanen, H. 1993. Ilomantsin Kuittilan ja Muurinsuon Au- ja Mo-W-mineralisaatioiden petrografia ja malmimineralogia. Unpublished MSc thesis. Department of Geology, University of Oulu. 108 p. (in Finnish)

Name	***Pampalo (Ward)***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Archaean **Belt** Ilomantsi
Map sheet	4333 07 **X coordinate** 6987700 **Y coordinate** 4564300
Municipality	Ilomantsi
Nearest town, access	40 km NE from Ilomantsi, 100 km NE from Joensuu. A sealed road 1 km from the area, a gravel road to the area.
MINING	
Exploration licence no.	4847/1, 5055/1, 5090/1.
Mining concession no.	4847/1a.
Present holder	Outokumpu Oyj 1994-.
Previous holders	Geological Survey of Finland 1990-1994 (GTK).
Status of development	Open pit and underground.
When mined	1996, 1997-.
Resources	1993: 0.59 Mt 7.9 ppm (cut off 2 ppm) [2, 3]; 1997: 0.6 Mt, 7.3 ppm Au [6,7,8].
Total production	330 kg Au [8].
Total in-situ gold	4.7 t Au [2,3,8].
Best sections	8 m at 46 ppm Au, 13 m at 8.8 ppm Au, 18 m at 8.9 ppm Au, 11 m at 8.6 ppm Au [1,2,3,4].
Extent of mineralisation	1997: 500 m long, 10-30 m wide zone, open at depth of 230 m.
Lodes	Three pipe-like, high-grade, subvertical, NE-trending bodies. The lodes are 5-10 m wide, 50-80 m in height and extend for >200 m down plunge (plunge 35° to NE) [2].
EXPLORATION	
Discovery	Discovered on 1990: Investigation of an outcrop in a structurally favourable location in an area of till-geochemical Au anomaly led to discovery of visible gold in the outcrop (by geologist Peter Sorjonen-Ward, GTK).
Exploration history	GTK (1986-1994) [1,2,3,4,7,11]: Detailed geochemical till sampling: sampling grid 250 x 250 m over the greenstone belt covering 400 km^2. Follow-up as till-bedrock interface geochemistry, samples collected across the Au anomaly along traverses 100 m apart with sampling distance 10-30 m. Low-altitude air- and ground-magnetic, slingram and IP survey. SIP investigations. Bedrock mapping based on outcrops, geophysics, trenching and diamond drilling. Special studies on Quaternary geology, ore mineralogy and geochemistry, and petrogenesis. A pilot enrichment study. Outokumpu (1994-) [9]: test pit in 1996, decline construction started 1997, followed by underground drilling from 1998 onwards.
Drilling	GTK (1990-1993) [1,2,3,4]: 90 diamond-drill holes, total 11924 m, 25 m distance between the drilling profiles.
Elements analysed	Ag, Al, As, Au, B, Ba, Bi, Ca, Cd, Co, CO_2, Cr, Cu, Fe, K, LOI, Mg, Mo, Na, Nb, P, Pb, Rb, REE, S, Sb, Sc, Se, Si, Sr, Te, Ti, Th, U, V, W, Y, Zn, Zr [1,2,5,6]. [12]: Main components, Cl, Sn and Zr by XRF; Ag, As, Au, Bi, Pd, Sb, Se and Te by GFAAS; Hg by wet-chemical method; B by DCP; Ba, Cd, Co, Cr, Ga, La, Li, Mo, Nb, Ni, Pb, Rb, Sb, Sc, Sr, Th, Tl, U, V, W, Y and Zn by ICP; CO_2 and S by Leco.
Economic evaluations	Preliminary feasibility study by Outokumpu on 1997-1998.
Geophysical response	No response on magnetic, slingram or IP methods. Magnetic and electric methods do show the structural features of the area, including those which control gold mineralisation [2].
Primary dispersion	Au, S, Se, Te and W enriched in all host rocks; K and LOI enrichment in metatuffite, but depletion in porphyries. In metatuffite, Au has best correlation with Te, S, W and Ag, and in porphyry with S, Se and Pb. No consistent chemical zoning found yet [2,5,6].
Secondary dispersion	[2]: Regional Au, As and B till anomaly, local Au, Te and Bi anomaly. Au content within the till anomaly is from tens of ppb to >1 ppm. Best combination for defining exploration targets: Au + Te + Bi – better than Au alone. [7]: Local peat deposits are anomalous on Au, As, Cu, Mo, Ni, S and Te. In peat, Au has the best positive correlation with Te. In addition, Au also has a weak positive correlation with Cl, K, Pb and Zn. The highest enrichment in peat is shown by As (100x normal peat in Finland. However, As does not show any correlation with Au. The most extensive peat anomalies are defined by As and Te.
Exploration geologist(s) in charge	Outokumpu: Esa Sandberg. GTK: Matti Damsten.
ORE	
Siting of gold	Free, fine-grained gold homogeneously disseminated through the mineralised zones: 1) at pyrite grain boundaries and as inclusions in pyrite with chalcopyrite and pyrrhotite, 2) in fractures of pyrite grains, 3) intergrown with tellurides amongst silicates, 4) intergrown with titanite, rutile and goethite, 5) as inclusions in K feldspar, quartz, biotite and calcite. Minor amounts of Au occurs as gold tellurides [1,2,4].
Fineness	69-98% Au (avg. 91%), 8% Ag (avg.) [2].
Major opaques	Pyrrhotite, pyrite [1, 2, 4]
Minor opaques	Rutile, chalcopyrite, galena, sphalerite, molybdenite, gold, tellurobismuthinite, tsumoite, frohbergite, altaite, hessite, petzite, calaverite, volynskite, rucklidgeite, electrum, bismuth, haematite, ilmenite, cubanite, mackinawite,

pentlandite [1,2,4].

Gangue Quartz, tourmaline, albite, K feldspar, biotite, muscovite, garnet, calcite, chlorite, scheelite, titanite [1,2,4].

Ore composition Diamond-drill core [12]: 8.30 ppm Au, 3.7 ppm Ag, 17.7 ppm As, 46 ppm B, 846 ppm Ba, 1.78 ppm Bi, 19.4 ppm Co, 232 ppm Cu, 26 ppb Hg, 65.2 ppm Li, 3.5 ppm Mo, 83.8 ppm Ni, 57 ppm Pb, 94 ppm Rb, 5700 ppm S, 2.53 ppm Sb, 1.82 ppm Se, 456 ppm Sr, 6.90 ppm Te, 21 ppm Th, 0.700 ppm Tl, 6.8 ppm U, 151 ppm V, 12 ppm W, 526 ppm Y, 126 ppm Zn, 348 ppm Zr; 59.9% SiO_2, 0.54% TiO_2, 16.2% Al_2O_3, 5.60% Fe_2O_3, 5.68% MgO, 0.62% CaO, 5.68% Na_2O, 4.20% K_2O, 0.24% P_2O_5.

Enriched elements Au + Ag, Ba, Bi, Cu, Li, Pb, Sb, Se, Te, W, Se, B, K, Rb, S, CO_2 (As, Zn) [2,5,6].

Ore fluid Fluid inclusions: max T = 250-260C, salinity 5-7 wt.% NaCl eq. [2].

Stable isotope data $\delta^{18}O$ (SMOW): +9.58 – +18.79‰ (calcite), +11.2‰ (quartz), +9.4‰ (albite), +4.0‰ (biotite); => T = 360-470°C; δD (SMOW): -86‰ (biotite); $\delta^{13}C$ (PDB): -9.15 – -8.18‰ (calcite) [2].

GEOLOGY

Major host rocks Intermediate metatuffite [2].

Minor host rocks Felsic porphyry, metakomatiite [2].

Geological setting The mineralisation is in the central part of the Hattu Schist Belt. The hosts rocks form a deformed sequence with tholeiitic metavolcanic rocks [2].

Intrusives Felsic porphyries in the host rocks and the nearest pluton (Tasanvaara tonalite) predate mineralisation. The age of the tonalitic plutons bounding the schist belt is ca. 2750 Ma [2].

METAMORPHISM

Metamorphic history [2]: Progressive regional metamorphism on ca. 2750-2700 Ma, apparently peaked soon after gold mineralisation, at a temperature of about 550±50°C. Thermal peak was synchronous or outlasted deformation.

Metamorphic grade Formation of post-mineralisation tremolite porphyroblasts in the metakomatiite. Greenschist-amphibolite facies transition [2].

Metamorphic mineral assemblage Intermediate metavolcanic rocks: K feldspar-albite-tremolite-biotite-sericite-calcite (-quartz-epidote-titanite-rutile-garnet-tourmaline) [2].

Porphyries: quartz-albite-actinolite [2].

Metakomatiites: talc-carbonate-chlorite-biotite-tremolite [2].

STRUCTURAL SETTING

Structural style Brittle-ductile.

Closest major shear The Pampalo Shear Zone system: a major shear zone on the both sides of the deposit [10].

Controlling structure Secondary shear zones between the main shear zones in the Pampalo shear system: SW-NE trending, complex, dominantly sinistral strike-slip(?) system; a duplex in the area. The mineralisation is in the NW margin of the duplex where numerous faults converge [2,10].

Deformation history Rapid and extensive crustal generation and deformation between 2.76-2.73 Ma. Formation of the strike-slip duplex predates mineralisation which apparently took place during the deformation of the toe of the duplex, attributed to rotational back-folding as relatively greater amounts of sinistral shear strain were transferred from the Pampalo Shear System to the Kelokorpi Shear Zone somewhat further west [2].

Veins Pre-mineralisation quartz veins with scheelite and molybdenite. Only minor, gold-related quartz-tourmaline ± K-feldspar veins [2].

ALTERATION

General alteration Formation of quartz, biotite, K feldspar, albite, calcite, chlorite, epidote, pyrite, rutile, tremolite-actinolite, tourmaline [2].

Proximal alteration Intermediate metatuffite: biotite-quartz-pyrite mineral assemblage [2].

TIMING Either pre-peak metamorphic and formed under greenschist-facies conditions, or syn-peak metamorphic. Minimum age 2708-2693 Ma (U-Pb of titanite and monazite indicating peak metamorphism) [2].

GENETIC MODEL [2]: Formed in a structurally favourable, the most competent lithological units in the area. Precipitation of gold by desulphidation of fluid and, possibly, by decomposition of Au-Te complexes of fluid due to cooling and/or changes in pH and fO_2. Probably, gold precipitated just below 500°C with sulphides. The formation of the present low-temperature Te and Bi minerals most probably took place as subsolidus reactions with cooling temperature. The combination of arsenopyrite and oxygen isotope thermometry, sphalerite geobarometry, with the dominance of pyrrhotite and calcite instated of pyrite and dolomite, respectively, suggests uppermost-greenschist facies or conditions transitional between breenschist and amphibolite facies for mineralisation: T = 450-500°C, p = 2-3 kbar.

Post-mineralisation modifications

[2]: Probably, an Archaean post-mineralisation metamorphic overprint at about 500±50°C with deformation and porphyroblast overgrowth. This also affected the $\delta^{18}O$ values of minerals. On ca. 1800 Ma, a Proterozoic regional metamorphic overprint which is shown by K-Ar and Rb-Sr ages of micas. Post-mineralisation, Archaean or Proterozoic, tremolite porphyroblasts are common in the metakomatiite.

FIGURES [2]: Regional geology map, regional till Au, As, B, Bi, Cu, Te and W maps, local surface geology maps ,cross section, ore photomicrograph.

References

1. Damsten, M., Nurmi, P., Sorjonen-Ward, P. & Hartikainen, A.. 1994. Tutkimustyöselostus Ilomantsin kunnassa valtausalueilla Pampalo 1 (kaivosrek. no. 4847/1), Pampalo 2 (kaivosrek. no. 5055/1) ja Pampalo 3 (kaivosrek. no. 5090/1) suoritetuista kultamalmitutkimuksista vuosina 1990-1993. Report on exploration on tenements Pampalo 1, Pampalo 2 & Pampalo 3, Ilomantsi. English summary. Geological

Survey of Finland, unpublished report M046/4333/-94/1/10. 34 p.
2. Nurmi, P. A. & Sorjonen-Ward, P. (eds) 1993. Geological Development, Gold Mineralization and Exploration Methods in the Late Archaean Hattu Schist Belt, Ilomantsi, Eastern Finland. Geological Survey of Finland, Special Paper 17. 386 p.
3. Nurmi, P.A. 1993. Archaean Au in Finland. Engineering and Mining Journal, Nov., 32-34.
4. Nurmi, P., Kojonen, K., Johanson, B. & Pakkanen, L. 1994. Ilomantsin Wardin kultaesiintymän malmimineralogia ja rikastettavuus. Report on ore mineralogy and gold enrichment tests on the Ward deposit, Ilomantsi. English summary. Geological Survey of Finland, unpublished report M19/4333/-93/1/10. 23 p.
5. Rasilainen, K. 1996. Alteration geochemistry of gold occurrences in the late Archean Hattu Schist Belt, Ilomantsi, Eastern Finland. Academic dissertation: synopsis and four research papers. Geological Survey of Finland.140 p.
6. Rasilainen, K .1997. Geochemistry of hydrothermal alteration at the late Archaean Pampalo gold deposit, eastern Finland. In: H. Papunen (ed.) Mineral Deposits: Research and Exploration - Where Do They Meet? Balkema, Rotterdam. 297-300.
7. Virtanen, K. 1997. Turpeen geokemialliset tutkimukset Ilomantsin Pampalossa (4333 07). Geological Survey of Finland, Report P4.45.003. (in Finnish)
8. Outokumpu Oy 1997. Annual Report 1996. Espoo.
9. Outokumpu Oyj 1997. Outokumpu to conduct further exploration of Pampalo gold deposit in Ilomantsi, Finland. Press release 23/6/1997.
10. Sorjonen-Ward, P. 1998. Personal communication 22/10/98.
11. Vanhala, H. 1997. Laboratory and field studies of environmental and exploration applications of the spectral induced-polarization (SIP) method. Geological Survey of Finland. 104 p.
12. Bornhorst, T. & Nurmi, P. (1999) Personal communication 20/1/1999.

Name	***Rämepuro***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Archaean **Belt** Ilomantsi
Map sheet	4244 09 **X coordinate** 6977700 **Y coordinate** 4564500
Municipality	Ilomantsi
Nearest town, access	35 km NE from Ilomantsi, 100 km NE from Joensuu. A sealed road 500 m from the area.
MINING	
Mining concession no.	3831/1a.
Present holder	Outokumpu Oyj.
Status of development	Prospect.
Resources	0.25 Mt 5 ppm Au (down to 50-70 m depth) [3].
Total in-situ gold	1.25 t Au [3].
Extent of mineralisation	500 m long, 1.5-10 m wide, open at 70 m depth [3,4]. Auriferous veins in a zone 300 m wide [7].
Lodes	The N-S trending, subvertical lode is formed by discontinuous auriferous quartz-tourmaline veins and dissemination in tonalitic porphyry dike [3,4].
EXPLORATION	
Discovery	Discovered on 1984 by Outokumpu Oy [2,4,5,7]: reanalysis of a sulphide-bearing outcrop sample. The sample was originally found by an amateur prospector on 1970. The sample contained 93 ppm Au, 75 ppm Ag and 0.4% Cu.
Exploration history	Outokumpu 1985-1988 [1,3,4,5,7]: Outcrop mapping, ground geophysical surveys, diamond drilling in profiles 50-100 m apart. Detailed geochemical till sampling: sampling grid 250 x 250 m over the greenstone belt covering 400 km^2. Follow-up as till-bedrock interface geochemistry, samples collected across the Au anomaly along traverses 100 m apart with sampling distance 10-30 m. Low-altitude air- and ground-magnetic, slingram and IP survey. Bedrock mapping based on outcrops, geophysics, trenching and diamond drilling. Special studies on Quaternary geology, ore mineralogy and geochemistry, and petrogenesis.
Drilling	Outokumpu (-1993) [3,4,5]: 29 drill holes, total 4043 m, traverse interval 50-100 m; on 1997: a set of short diamond-drill holes.
Elements analysed	[8]: Main components, Cl, Sn and Zr by XRF; Ag, As, Au, Bi, Pd, Sb, Se and Te by GFAAS; Hg by wet-chemical method; B by DCP; Ba, Cd, Co, Cr, Ga, La, Li, Mo, Nb, Ni, Pb, Rb, Sb, Sc, Sr, Th, Tl, U, V, W, Y and Zn by ICP; S by Leco. [7]: Major elements and certain trace elements by XRF, most of the trace elements by AAS.
Economic evaluations	Preliminary evaluation by Outokumpu during 1990's [1].
Geophysical response	Shear zone and shear-related alteration envelope has a weak response on IP (ground survey). Gold mineralisation also has an response on IP [3].
Primary dispersion	Au and Te show good correlation; Ag and Bi show moderate correlation with Au; no consistent chemical zoning found [3,7].
Secondary dispersion	[3]: Regional Au, As and B till anomaly, local Au, Te and Bi anomaly. Au content within the till anomaly is from tens of ppb to >1 ppm. Best combination for defining exploration targets: Au + Te + Bi - better than Au alone.
Exploration geologist(s) in charge	Outokumpu: Esa Sandberg. GTK: Matti Damsten.
ORE	
Siting of gold	Chiefly free gold which occurs between quartz and tourmaline grains and their fractures, associated with sulphides, bismuth and tellurides [3,7]. Some gold occurs as inclusions in pyrite and pyrrhotite [3,7].
Fineness	86-99% Au, 0-12% Ag, 0.02-0.53% Cu [3,7].
Major opaques	Pyrrhotite, pyrite [3,4,7].
Minor opaques	Gold, native bismuth, chalcopyrite, cubanite, sphalerite, hedleyite, arsenopyrite, molybdenite, mackinawite, molybdenite, ilmenite, rutile [3,4,7].
Gangue	Quartz, albite, K feldspar, biotite, muscovite, garnet, calcite, siderite, chlorite, scheelite, titanite, tourmaline [3,7].
Ore composition	Diamond-drill core [8]: 4.70 ppm Au, 4.10 ppm Ag, 20 ppm As, 1830 ppm B, 859 ppm Ba, 361 ppm Bi, 38 ppm Co, 140 ppm Cu, 91 ppb Hg, 56 ppm Li, <1.0 ppm Mo, 121 ppm Ni, <2 ppm Pb, 65 ppm Rb, 15400 ppm S, 0.2 ppm Sb, 0.32 ppm Se, 290 ppm Sr, 3.70 ppm Te, 4.2 ppm Th, 0.80 ppm Tl, 1.9 ppm U, 120 ppm V, 12 ppm W, 8 ppm Y, 90 ppm Zn, 88 ppm Zr; 67.2% SiO_2, 0.57% TiO_2, 15.0% Al_2O_3, 7.46% Fe_2O_3, 1.92% MgO, 0.90% CaO, 1.95% Na_2O, 2.70% K_2O, 0.05% P_2O_5.
Enriched elements	Au, Te, Bi, B, Ag, As, W, Se, B, K, Li, Rb, S, CO_2 [3,6].
Ore fluid	Fluid inclusions: max T = 240-310°C, salinity 6-12 wt.% NaCl eq. [3]. The present ore mineral parageneses suggest that T = 250-340°C [7]. Occurrence of cubanite lamellae in chalcopyrite indicates T>250°C.
Stable isotope data	$\delta^{18}O$ (SMOW): +6.3 - +8.7‰ (quartz), +9.0‰ (tourmaline); δD (SMOW): -96‰ (tourmaline), -82‰ (muscovite) [3].
GEOLOGY	
Major host rocks	Tonalitic porphyry dyke [2,3,4,5,7].
Minor host rocks	Metagreywacke [7].

Geological setting The mineralisation is in the central part of the Hattu Schist Belt, at a contact zone between an andesitic pyroclastic metavolcanic rock and a mica schist of sedimentary origin both deposited in an island-arc environment [7]. All igneous rocks in the area have a calc-alkaline character [3,7].

Intrusives The tonalitic porphyry host rock predates mineralisation. Tonalite intrusions bound the greenstone belt in the area. In the east, a pre-mineralisation(?) intrusion with U-Pb zircon age of ca. 2.750 Ga cut across the greenstone belt rocks. Post-mineralisation Proterozoic dolerites cross cut all the other rocks, mineralisation and alteration in the area. [2,3,4,5]

METAMORPHISM

Metamorphic history Progressive regional metamorphism on ca. 2750-2700 Ma, apparently peaked soon after gold mineralisation, at a temperature of about 550±50°C [3]. Garnet-biotite pairs indicate metamorphic temperature variation from 390 to 580°C, suggesting polyphase metamorphism with a strong retrograde content [3,7]. The thermal peak was synchronous or outlasted deformation [3].

Metamorphic grade Greenschist-amphibolite facies transition [3].

Metamorphic mineral assemblage Quartz-plagioclase-biotite-chlorite-muscovite-actinolite-garnet-K feldspar [3,7].

STRUCTURAL SETTING

Structural style Brittle-ductile.

Closest major shear Tsurkkila Shear Zone adjacent to the deposit [3,10].

Controlling structure N-S trending Tsurkkila shear zone to the west of the deposit [3].

Veins Discontinuous quartz-tourmaline veins containing minor to trace amounts of biotite, chlorite, muscovite, plagioclase, sulphides, and gold [3,7]. Post-gold mineralisation veins filled by albite and laumontite [7].

ALTERATION

General alteration Formation of the assemblage quartz-muscovite-albite-biotite-chlorite-tourmaline-calcite-garnet-epidote [3,7]. Alteration envelope is 20-30 m wide (containing the main mineralisation and the mineralised shear zone in both the porphyry and metagreywacke) [3]. Apparent zoning only within 1 cm of the veins [7].

Proximal alteration Quartz-sericite-biotite-chlorite-tourmaline-calcite-rutile-garnet-epidote; slightly more intense formation of quartz in the innermost parts of the shear zone [3,6].

TIMING Either pre-peak metamorphic and formed under greenschist-facies conditions, or syn-peak metamorphic; minimum age 2708-2693 Ma (U-Pb of titanite and monazite indicating peak metamorphism) [2,6]. Post-peak metamorphic, retrograde [7].

GENETIC MODEL Formed in a structurally favourable, the most competent lithological units in the area. Precipitation of gold by desulphidation of fluid and, possibly, by decomposition of Au-Te complexes of fluid due to cooling and/or changes in pH and fO_2. Gold probably precipitated just below 500°C with sulphides. The formation of the present low-temperature Te and Bi minerals most probably took place as subsolidus reactions with cooling temperature. The combination of arsenopyrite and oxygen isotope thermometry, sphalerite geobarometry, with the dominance of pyrrhotite and calcite instated of pyrite and dolomite, respectively, suggests uppermost-greenschist facies or conditions transitional between breenschist and amphibolite facies for mineralisation: T = 450-500°C, p = 2-3 kbar [3]. According to [7], auriferous veins were formed during the intrusion of syn- or late-orogenic granitoids when sets of conjugate Reidel faults and/or tensional fractures were formed.

Post-mineralisation modifications

[3]: Probably, an Archaean post-mineralisation metamorphic overprint at about 500±50°C with deformation and porphyroblast overgrowth. This also affected $\delta^{18}O$ values of minerals. On ca. 1800 Ma, a Proterozoic regional metamorphic overprint which is shown by K-Ar and Rb-Sr ages of micas.

FIGURES [3]: Regional geology map, regional till Au, As, B, Bi, Cu, Te and W maps, local surface geology map, cross section, ore photomicrograph.
[7]: Thin section photomicrographs, surface map, cross section.

References

1. Nurmi, P. A. 1993. Archaean Au in Finland. Engineering and Mining Journal, Nov., 32-34.
2. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
3. Nurmi, P. A. & Sorjonen-Ward, P. (eds) 1993. Geological Development, Gold Mineralization and Exploration Methods in the Late Archaean Hattu Schist Belt, Ilomantsi, Eastern Finland. Geological Survey of Finland, Special Paper 17. 386 p.
4. Ojala, V. J., Pekkarinen, L. J., Piirainen, T. & Tuukki, P. 1990. The Archaean gold mineralization in Rämepuro, Ilomantsi greenstone belt, eastern Finland. Terra Nova 2, 240-244.
5. Pekkarinen, L. J. 1988. The Hattuvaara gold occurrence, Ilomantsi: a case history. Annales Universitatis Turkuensis, Sarja C. Tom 67, 79-87.
6. Rasilainen, K. 1996. Rasilainen, K. (1996) Alteration geochemistry of gold occurrences in the late Archean Hattu Schist Belt, Ilomantsi, Eastern Finland. Academic dissertation: synopsis and four research papers. Geological Survey of Finland.140 p.
7. Ojala, J. 1988. Ilomantsin Hattuvaaran Rämepuron Au-mineralisaation geologia. Unpublished MSc thesis. Department of Geology, University of Oulu. 78 p. (in Finnish)
8. Bornhorst, T. & Nurmi, P. (1999) Personal communication 20/1/1999.

Name	***Valkeasuo (Hosko)***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Archaean **Belt** Ilomantsi
Map sheet	4333 05 **X coordinate** 6998000 **Y coordinate** 4559200
Municipality	Ilomantsi
Nearest town, access	40 km NE from Ilomantsi, 100 km NE from Joensuu. A sealed road 300 m from the area.
MINING	
Present holder	Endomines Oy.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	9 m at 2.2 ppm Au [1].
EXPLORATION	
Discovery	On 1992 by the GTK.
Exploration history	GTK (1987-1993) [1,2,4]: Detailed geochemical till sampling: sampling grid 250 x 250 m over the greenstone belt covering 400 km^2. Follow-up as till-bedrock interface geochemistry, samples collected across the Au anomaly along traverses 100 m apart with sampling distance 10-30 m. Low-altitude air- and ground-magnetic, slingram and IP survey. Bedrock mapping based on outcrops, geophysics, trenching and diamond drilling. Special studies on Quaternary geology, ore mineralogy and geochemistry, and petrogenesis. SIP investigations. Endomines Oy (1996-) [3]: RC and diamond drilling.
Drilling	GTK: (1987-1993) [1]: 4 diamond-drill holes, total 607 m.
Elements analysed	[5]: Main components, Cl, Sn and Zr by XRF; Ag, As, Au, Bi, Pd, Sb, Se and Te by GFAAS; Hg by wet-chemical method; B by DCP; Ba, Cd, Co, Cr, Ga, La, Li, Mo, Nb, Ni, Pb, Rb, Sb, Sc, Sr, Th, Tl, U, V, W, Y and Zn by ICP; C and S by Leco.
Geophysical response	[2]: No response on magnetic, slingram or IP methods. Magnetic and electric methods do show the structural features of the area, including those which control gold mineralisation.
Primary dispersion	[2]: Au and Te show good correlation; Ag and Bi show moderate correlation with Au. No consistent chemical zoning found yet.
Secondary dispersion	[2]: Regional Au, As and B till anomaly, local Au, Te and Bi anomaly. Au content within the till anomaly is from tens of ppb to >1 ppm. Best combination for defining exploration targets: Au + Te + Bi - better than Au alone.
Exploration geologist(s) in charge	Endomines Oy: Timo Lindborg; GTK: Matti Damsten.
ORE	
Siting of gold	Dissemination in mica schist [1].
Major opaques	Pyrrhotite, pyrite [5].
Minor opaques	Arsenopyrite [5].
Gangue	Quartz, sericite, tourmaline [5].
Ore composition	Diamond-drill core [5]: 10.20 ppm Au, 1.60 ppm Ag, 1740 ppm As, 1400 ppm B, 514 ppm Ba, 1.13 ppm Bi, 13.9 ppm Co, 53.6 ppm Cu, 16 ppb Hg, 14.1 ppm Li, 1.5 ppm Mo, 28.9 ppm Ni, 3.2 ppm Pb, 80 ppm Rb, 8400 ppm S, 3.73 ppm Sb, 0.41 ppm Se, 491 ppm Sr, 3.00 ppm Te, 5.4 ppm Th, 1.00 ppm Tl, 1.9 ppm U, 96 ppm V, 230 ppm W, 16 ppm Y, 167 ppm Zn, 161 ppm Zr; 67.9% SiO_2, 0.47% TiO_2, 16.29% Al_2O_3, 4.63% Fe_2O_3, 0.33% MgO, 2.40% CaO, 3.78% Na_2O, 1.80% K_2O, 0.15% P_2O_5.
Enriched elements	Au, Ag, As, B, Ba, Bi, S, Sb, Te, W [5].
GEOLOGY	
Major host rocks	Mica schist (intermediate metatuffite?) [1].
Geological setting	The mineralisation is in the northern part of the Hattu Schist Belt [2].
Intrusives	The nearest plutons clearly predate mineralisation. The age of the tonalitic plutons bounding the schist belt is ca. 2750 Ma [2].
METAMORPHISM	
Metamorphic history	[2]: Progressive regional metamorphism on ca. 2750-2700 Ma, apparently peaked soon after gold mineralisation, at a temperature of about 550±50°C. Thermal peak was synchronous or outlasted deformation.
Metamorphic grade	Greenschist-amphibolite facies transition [2].
STRUCTURAL SETTING	
Closest major shear	Rosvohotu Shear Zone system 200 m west from the deposit [2].
Controlling structure	N-S trending Rosvohotu shear zone [2].
ALTERATION	
General alteration	Sericitisation is most prominent; alteration predates the final stages of deformation within the shear zone [2,3].
TIMING	[2]: Either pre-peak metamorphic and formed under greenschist-facies conditions, or syn-peak metamorphic. Minimum age 2708-2693 Ma (U-Pb of titanite and monazite indicating peak metamorphism).

GENETIC MODEL [2]: Formed in a structurally favourable, the most competent lithological units in the area. Precipitation of gold by desulphidation of fluid and, possibly, by decomposition of Au-Te complexes of fluid due to cooling and/or changes in pH and fO_2. Probably, gold precipitated just below 500°C with sulphides. The formation of the present low-temperature Te and Bi minerals most probably took place as subsolidus reactions with cooling temperature.

Post-mineralisation modifications

[2]: Probably, an Archaean post-mineralisation metamorphic overprint at about 500±50°C with deformation and porphyroblast overgrowth. On ca. 1800 Ma, a Proterozoic regional metamorphic overprint which is shown by K-Ar and Rb-Sr ages of micas.

FIGURES [2]: Regional geology map, regional till Au, As, B, Bi, Cu, Te and W maps.

References

1. Nurmi, P. A. 1993. Archaean Au in Finland. Engineering and Mining Journal, Nov., 32-34.
2. Nurmi, P. A. & Sorjonen-Ward, P. (eds) 1993. Geological Development, Gold Mineralization and Exploration Methods in the Late Archaean Hattu Schist Belt, Ilomantsi, Eastern Finland. Geological Survey of Finland, Special Paper 17. 386 p.
3. Lindborg, T. 1997. Personal communication 2/10/1997.
4. Vanhala, H. 1997. Laboratory and field studies of environmental and exploration applications of the spectral induced-polarization (SIP) method. Geological Survey of Finland. 104 p.
5. Bornhorst, T. & Nurmi, P. (1999) Personal communication 20/1/1999.

Name	***Viinivaara***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Archaean **Belt** Ilomantsi
Map sheet	4244 07 **X coordinate** 6957850 **Y coordinate** 4561100
Municipality	Ilomantsi
Nearest town, access	15 km NE from Ilomantsi. 10 km to a sealed road, 500 m to a gravel road.
MINING	
Present holder	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	5 m at 1.4 ppm Au (1993) [1].
EXPLORATION	
Discovery	On 1986 by the GTK.
Exploration history	GTK (1986-) [1,2]: Detailed geochemical till sampling: sampling grid 250 x 250 m over the greenstone belt covering 400 km^2. Follow-up as till-bedrock interface geochemistry, samples collected across the Au anomaly along traverses 100 m apart with sampling distance 10-30 m. Low-altitude air- and ground-magnetic, slingram and IP survey. Bedrock mapping based on outcrops, geophysics, trenching and diamond drilling. Special studies on Quaternary geology, ore mineralogy and geochemistry, and petrogenesis.
Drilling	GTK (-1993) [1]: 6 diamond-drill holes, 654 m.
Geophysical response	[2]: No response on magnetic, slingram or IP methods. Magnetic and electric methods do show the structural features of the area, including those which control gold mineralisation.
Primary dispersion	[2]: Au and Te show good correlation; Ag and Bi show moderate correlation with Au. No consistent chemical zoning found yet.
Secondary dispersion	[2]: Regional Au, As and B till anomaly, local Au, Te and Bi anomaly. Au content within the till anomaly is from tens of ppb to >1 ppm. Best combination for defining exploration targets: Au + Te + Bi – better than Au alone.
Exploration geologist(s) in charge	GTK: Matti Damsten.
ORE	
Siting of gold	Dissemination in mica schist [1].
Major opaques	Pyrrhotite, pyrite [1].
Enriched elements	Au + B, CO_2, K, Rb, S [1].
GEOLOGY	
Major host rocks	Mica schist [1].
Geological setting	The mineralisation is in the southern part of the Hattu Schist Belt [2].
Intrusives	The nearest plutons clearly predate mineralisation. The age of the tonalitic plutons bounding the schist belt is ca. 2750 Ma [2].
METAMORPHISM	
Metamorphic history	[2]: Progressive regional metamorphism on ca. 2750-2700 Ma, apparently peaked soon after gold mineralisation, at a temperature of about 550±50°C. Thermal peak was synchronous or outlasted deformation.
Metamorphic grade	Greenschist-amphibolite facies transition [2].
STRUCTURAL SETTING	
Closest major shear	Between the Kelokorpi and Tsurkkila Shear Zones or adjacent to the Kelokorpi Shear Zone; these shear zones have here a N-S trend [2].
Controlling structure	Subsidiary shear or fault zones related to the Kelokorpi Shear Zone? [2].
TIMING	[2]: Either pre-peak metamorphic and formed under greenschist-facies conditions, or syn-peak metamorphic. Minimum age 2708-2693 Ma (U-Pb of titanite and monazite indicating peak metamorphism).
GENETIC MODEL	[2]: Formed in a structurally favourable, the most competent lithological units in the area. Precipitation of gold by desulphidation of fluid and, possibly, by decomposition of Au-Te complexes of fluid due to cooling and/or changes in pH and fO_2. Probably, gold precipitated just below 500°C with sulphides. The formation of the present low-temperature Te and Bi minerals most probably took place as subsolidus reactions with cooling temperature.
Post-mineralisation modifications	[2]: Probably, an Archaean post-mineralisation metamorphic overprint at about 500±50°C with deformation and porphyroblast overgrowth. This also affected $\delta^{18}O$ values of minerals. On ca. 1800 Ma, a Proterozoic regional metamorphic overprint which is shown by K-Ar and Rb-Sr ages of micas.
FIGURES	[2]: Regional geology map, regional till Au, As, B, Bi, Cu, Te and W maps.

References

1. Nurmi, P. A. 1993. Archaean Au in Finland. Engineering and Mining Journal, Nov., 32-34.
2. Nurmi, P. A. & Sorjonen-Ward, P. (eds) 1993. Geological Development, Gold Mineralization and Exploration Methods in the Late Archaean Hattu Schist Belt, Ilomantsi, Eastern Finland. Geological Survey of Finland, Special Paper 17. 386 p.

Name	***Aittoranta***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Archaean **Belt** Kuhmo
Map sheet	4412 11 **X coordinate** 7144500 **Y coordinate** 4455200
Municipality	Kuhmo
Nearest town, access	38 km NW from Kuhmo. 2 km from a sealed road, a gravel road to the area.
MINING	
Present holder	Geological Survey of Finland (GTK).
Status of development	Prospect.
Extent of mineralisation	A few hundred metres long and 2-20 m wide zone, open at both ends and in depth [1].
Lodes	The mineralised zone may, in fact, comprise a set of narrow, parallel subzones [1].
EXPLORATION	
Discovery	On 1992: a mineralised sample from outcrop provided to GTK by an amateur prospector [1].
Exploration history	GTK [1]: bedrock mapping, trenching, diamond drilling.
Drilling	GTK: 5 diamond-drill holes [1].
Exploration geologist(s) in charge	
	GTK: Erkki Luukkonen.
ORE	
Major opaques	Arsenopyrite [1].
Gangue	Quartz, tourmaline [1].
Enriched elements	Au, As, B, S [1].
GEOLOGY	
Major host rocks	Mafic metavolcanic rock [1].
Minor host rocks	Felsic schist, metakomatiite [1,2].
Geological setting	Located in the northern part of the Late-Archaean Kuhmo Greenstone Belt [3].
METAMORPHISM	
Metamorphic grade	Transitional between greenschist and amphibolite facies [1].
STRUCTURAL SETTING	
Structural style	Ductile(-brittle).
Closest major shear	Ductile, N-S trending, subvertical, several hundreds of metres wide shear zone [1].
Controlling structure	The mineralisation is in the eastern margin of the major shear zone [1,2].
Deformation history	At least, six deformation stages during the late Archaean and two deformation stages during the Palaeoproterozoic time detected in the area; gold mineralisation is related to the Archaean late D3 and/or D4 stages [3].
Veins	Quartz-tourmaline veins up to 50 cm wide, quartz-tourmaline breccia [1].
ALTERATION	
General alteration	Tourmalinisation and biotitisation [1].
TIMING	Late Archaean [3].
GENETIC MODEL	Clearly epigenetic, “mesothermal” mineralisation with a distinct structural control [1,3].

References

1. Pietikäinen, K. 1998. Personal communication 14/9/98.
2. Luukkonen, E. 1998. Personal communication 27/10/98.
3. Luukkonen, E., Pajunen, M. & Poutiainen, M. 1992. Kuhmo-Suomussalmen alueen arkeeisen kallioperän rakenne-evoluutio ja Au-aiheet. In: E. Ekdahl (ed.) Suomen kallioperän kehitys ja raaka-ainevarat. Vuorimiesyhdistys, Sarja B, 51, 11-12.

Name	***Jousijärvi***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Archaean **Belt** Kuhmo
Map sheet	4412 11 **X coordinate** 7141740 **Y coordinate** 4455730
Municipality	Kuhmo
Nearest town, access	40 km NW from Kuhmo. 1 km from a sealed road.
MINING	
Exploration licence no.	4876/1.
Present holder	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	2.6 m at 3.5 ppm Au.
EXPLORATION	
Discovery	By GTK: regional Au anomaly in till was the first indication; the mineralisation was detected by diamond drilling into a local Au anomaly in till [1].
Exploration history	GTK [1]: bedrock mapping, diamond drilling, till geochemical and stratigraphy survey.
Exploration geologist(s) in charge	
	GTK: Erkki Luukkonen, Timo Heino.
GEOLOGY	
Major host rocks	Mafic to felsic metavolcanic rocks [2]
Geological setting	Located in the northern part of the Late-Archaean Kuhmo Greenstone Belt [2].
METAMORPHISM	
Metamorphic grade	Transitional between upper-greenschist and lower-amphibolite facies [2].
STRUCTURAL SETTING	
Structural style	Ductile(-brittle) [2].
Closest major shear	A N-S trending, ductile, subvertical, several hundreds of metres wide shear zone [2].
Controlling structure	The mineralisation is in the eastern margin of the major shear zone in the area [2].
Deformation history	At least, six deformation stages during the late Archaean and two deformation stages during the Palaeoproterozoic time detected in the area; gold mineralisation is related to the Archaean late D3 and/or D4 stages [3].
Veins	Extensional quartz(-baryte) veins [2].
TIMING	Late Archaean [3].
GENETIC MODEL	Orogenic “mesothermal” deposit.

References

1. Pietikäinen, K. 1998. Personal communication 14/9/1998.
2. Luukkonen, E. 1998. Personal communication 27/10/98.
3. Luukkonen, E., Pajunen, M. & Poutiainen, M. 1992. Kuhmo-Suomussalmen alueen arkeeisen kallioperän rakenne-evoluutio ja Au-aiheet. In: E. Ekdahl (ed.) Suomen kallioperän kehitys ja raaka-ainevarat. Vuorimiesyhdistys, Sarja B, 51, 11-12.

Name	***Lokkiluoto***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Archaean **Belt** Kuhmo
Map sheet	4413 02 **X coordinate** 7115470 **Y coordinate** 4463910
Municipality	Kuhmo
Nearest town, access	12 km W from Kuhmo. Two small islets on the lake Ontojärvi, 4 km from sealed road, 1.5 km over the lake to a gravel road at the lake shore.
MINING	
Exploration licence no.	4969/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Kajaani Oy, Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	5.6 m at 4.2 ppm Au [1].
Extent of mineralisation	N-S trending, 1 m wide, 80 m long [2].
EXPLORATION	
Discovery	The mineralised outcrop was found by an amateur prospector [2].
Exploration history	Kajaani Oy (pre-1990) [2]: bedrock mapping, diamond drilling. GTK (1990-) [2]: bedrock mapping, low-altitude airborne magnetic, electric, gravity and radiometric survey, diamond drilling.
Drilling	Kajaani Oy [2]: two diamond-drill holes. GTK (1992) [2]: 8 diamond-drill holes, total 343 m.
Elements analysed	Ag, As, Au, Co, Cu, Fe, Ni, Pb, S, Te, and Zn [2].
Primary dispersion	Au and As anomaly, at least, in the hanging wall [2].
Exploration geologist(s) in charge	
	GTK: Timo Heino.
ORE	
Siting of gold	As inclusions and in margins of arsenopyrite and chalcopyrite [2].
Major opaques	Arsenopyrite [2].
Minor opaques	Pyrrhotite, chalcopyrite, ilmenite, pyrite, a telluride, gold, molybdenite [2].
Ore composition	Diamond-drill core [1]: 3.90 ppm Au, 0.225 ppm Ag, 8500 ppm As, 7.5 ppm B, 271 ppm Ba, 1.3 ppm Bi, 73 ppm Co, 319 ppm Cu, 150 ppb Hg, 2.0 ppm Mo, 55 ppm Ni, <2 ppm Pb, 51 ppm Rb, 10300 ppm S, 8.9 ppm Sb, 0.32 ppm Se, 148 ppm Sr, 0.150 ppm Te, 2.6 ppm Th, 1.3 ppm U, 280 ppm V, 5.0 ppm W, 235 ppm Zn; 49.7% SiO_2, 2.12% TiO_2, 12.1% Al_2O_3, 18.6% Fe_2O_3, 3.25% MgO, 7.99% CaO, 1.63% Na_2O, 1.04% K_2O, 0.36% P_2O_5, 1.16% LOI. Within the entire mineralisation: 1-9 ppm Au [2].
Enriched elements	Au, As, Bi, S, Sb, Te, W [1].
GEOLOGY	
Major host rocks	Mafic metatuff(ite) [1,2].
Minor host rocks	
Geological setting	The deposit is conformable; it is in the SW part of the late Archaean Kuhmo Greenstone belt, in the contact zone of the mafic to ultramafic-dominated Petäjäniemi Formation and the mica schist-dominated Kokkoniemi Formation [2].
STRUCTURAL SETTING	
Closest major shear	The deposit is between two NW-trending, mylonitised shear zones [2].
Controlling structure	D4-structure(s) [2].
Deformation history	At least, six deformation stages during the late Archaean and two deformation stages during the Palaeoproterozoic time detected in the area; gold mineralisation is related to the Archaean D4 stage [3].
ALTERATION	
General alteration	Biotitisation, weak sulphidation and precipitation of quartz [2].
TIMING	Late Archaean [3].
GENETIC MODEL	Orogenic “mesothermal” deposit.

References

1. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
2. Heino, T. & Kilpelä, M. 1995. Tutkimustyöselostus valtausalueella Lokki 1, kaivosrekisterinumero 4969/1 suoritetuista tutkimuksista. Geological Survey of Finland, unpublished report M06/4413/1995/1/10. 5 p. (in Finnish)
3. Luukkonen, E., Pajunen, M. & Poutiainen, M. 1992. Kuhmo-Suomussalmen alueen arkeeisen kallioperän rakenne-evoluutio ja Au-aiheet. In: E. Ekdahl (ed.) Suomen kallioperän kehitys ja raaka-ainevarat. Vuorimiesyhdistys, Sarja B, 51, 11-12.

Name	***Moukkori (Housuvaara 1)***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Archaean **Belt** Suomussalmi
Map sheet	4513 09 **X coordinate** 7243900 **Y coordinate** 4480850
Municipality	Suomussalmi
Nearest town, access	55 km NE from Suomussalmi. 5 km from sealed road, a gravel road to the area.
MINING	
Exploration licence no.	4876/1-2.
Present holder	Geological Survey of Finland (GTK).
Status of development	Prospect.
Resources	0.003401 Mt at 13.4 ppm Au [5].
Best sections	3.5 m at 39 ppm Au.
EXPLORATION	
Discovery	By GTK: a tiny mineralised outcrop found during exploration for base metals [4,7].
Exploration history	GTK (1990-97) [1,4,5,6,7]: Geological mapping, ground magnetic, slingram, VLF-R, total intensity and IP survey, till geochemical survey, RC and diamond drilling, trenching, detailed mineralogical study.
Drilling	GTK: 17 diamond-drill holes, total 1746 m [5,7].
Elements analysed	[9]: Main components, Cl, Sn and Zr by XRF; Ag, As, Au, Bi, Pd, Sb, Se and Te by GFAAS; Hg by wet-chemical method; B by DCP; Ba, Cd, Co, Cr, Ga, La, Li, Mo, Nb, Ni, Pb, Rb, Sb, Sc, Sr, Th, Tl, U, V, W, Y and Zn by ICP; S by Leco.
Exploration geologist(s) in charge	GTK: Erkki Luukkonen.
ORE	
Siting of gold	80% of gold is as free grains with gangue minerals, chiefly with quartz in quartz veins, 15% is as inclusions in practically all sulphides and tellurides, and some gold is in the lattice of the tellurides [1,3,5].
Fineness	6.1-13.4% Ag, inclusions: 18.4-22.4% Ag [1].
Major opaques	Pyrrhotite [1,4,7].
Minor opaques	Marcasite, pyrite, galena, sphalerite, chalcopyrite, altaite, hessite, volynskite, tsumoite, petzite, cervellite, gold, rutile, goethite [1,4,7].
Gangue	Quartz, scheelite, tourmaline [2,3,7].
Ore composition	Diamond-drill core [9]: 36.00 ppm Au, 6.90 ppm Ag, 5.2 ppm As, 33 ppm B, 241 ppm Ba, 920 ppm Bi, 26.5 ppm Co, 110 ppm Cu, 13 ppb Hg, 26.2 ppm Li, 2.1 ppm Mo, 26.3 ppm Ni, 124 ppm Pb, 59 ppm Rb, 10700 ppm S, 0.19 ppm Sb, 0.58 ppm Se, 192 ppm Sr, 2.20 ppm Te, 2.1 ppm Th, 0.40 ppm Tl, 1.2 ppm U, 210 ppm V, 2 ppm W, 30 ppm Y, 117 ppm Zn, 108 ppm Zr; 63.3% SiO_2, 1.04% TiO_2, 10.38% Al_2O_3, 9.82% Fe_2O_3, 3.28% MgO, 5.60% CaO, 1.47% Na_2O, 1.90% K_2O, 0.13% P_2O_5.
Enriched elements	Au, Ag, As, B, Bi, CO_2, K, Pb, S, Te [9].
Ore fluid	[2]: Low salinity H_2O-CO_2±CH_4 fluid(s); fluid inclusions: homogenisation T = 195-235°C, min. pressure <2.5 kbar.
GEOLOGY	
Major host rocks	“Uralite-porphyrite” [6].
Minor host rocks	Intermediate metatuffite [4].
Geological setting	The deposit is in the Tormua Schist Belt which forms the NE part of the late Archaean Suomussalmi Greenstone Belt [7].
Intrusives	[2]: TTG granitoids, from 2739±8 Ma to 2697±10 Ma of age, are abundant within and near the greenstone belt.
METAMORPHISM	
Metamorphic grade	Amphibolite facies [4].
Metamorphic mineral assemblage	Plagioclase-hornblende-biotite-quartz ± K feldspar, ilmenite [1].
STRUCTURAL SETTING	
Structural style	Ductile(-brittle) [2,4].
Controlling structure	A second-order D3 structure [3,5,7].
Deformation history	At least, four deformation stages during the late Archaean and two deformation stages during the Palaeoproterozoic time detected in the area; the controlling structure is related to the third phase (D3) of the regional structural evolution during the Archaean [1,3,7]. The latest Archaean stage, D4, has deformed the gold mineralisation [3].
Veins	Quartz veins [1,3,6].
ALTERATION	
General alteration	Mineral assemblage chlorite-sericite-epidote-calcite-quartz-rutile-ilmenite-pyrrhotite [1,2].
Proximal alteration	Quartz-biotite-epidote(?)-chlorite-plagioclase-K feldspar-sericite-calcite-pyrrhotite [1].
Distal alteration	The most distal alteration is probably indicated by the appearance of tremolite ± epidote and titanite [1].

TIMING [2]: Hydrothermal titanite gives an U-Pb age of 2676±20 Ma. This timing as the age for mineralisation is supported by structural evidence.

GENETIC MODEL [2]: Formed soon(?) after the peak metamorphic event under slightly retrograde conditions near the ductile-brittle transition zone. Deposition of gold occurred primarily as a consequence of sulphidation of iron from the mafic country rock.

Post-mineralisation modifications

Possibly, a retrograde overprint at greenschist-facies PT conditions [2].

References

1. Chernet, T. 1994. Ore mineralogy of the Moukkori gold prospect. Geological Survey of Finland, unpublished report M19/4513/-94/1/42. 16 p.
2. Poutiainen, M. & Luukkonen, E. 1994. The geology and fluid inclusion studies of some epigenetic gold deposits in the Archean Kuhmo and Suomussalmi greenstone belts, eastern Finland. In: M. G. Izquierdo, A. M. C. Suarez, G. M. Guevara, D. Vanko & G. J. C. Viaggio (eds) Fifth Biennial Pan-American Conference on Research on Fluid Inclusions, Cuernavaca, Morelos, Mexico, May 19-21, 1994. Abstracts, 77-78.
3. Luukkonen, E. 1993. Kultamineralisaatio Suomussalmen ja Kuhmon vihreäkivivyöhykkeellä. In: P. Nurmi (ed.) Itä-Suomen kultaesiintymät. Ekskursio-opas. Vuorimiesyhdistys, Sarja B, no. 54, 33-35. (in Finnish)
4. Pietikäinen, K. 1998. Personal communication 14/9/1998.
5. Ministry of Trade and Industry 1998. International tender notice. Tormua gold prospect, Suomussalmi, Finland. Press release 6/10/1998.
6. Luukkonen, E. 1998. Personal communication 27/10/98.
7. Luukkonen, E., Heino, T., Tenhola, M., Niskanen, M. & Hartikainen, A. 1997. Tutkimustyöselostus Suomussalmen kunnassa valtausalueella Saarilampi 1 (kaivosrekisteri 5351/1), Housuvaara 1-2 (kaivosrekisteri 4876/1-2), Mullikko 1 (kaivosrekisteri 5029/1), Pahka 1 (kaivosrekisteri 5029/2/1) ja Pahkalampi 1 (kaivosrekisteri 5232/1) suoritetuista kultamalmitutkimuksista vuosina 1990-1997. Geological Survey of Finland, unpublished report. 21 p. (in Finnish)
8. Luukkonen, E., Pajunen, M. & Poutiainen, M. 1992. Kuhmo-Suomussalmen alueen arkeeisen kallioperän rakenne-evoluutio ja Au-aiheet. In: E. Ekdahl (ed.) Suomen kallioperän kehitys ja raaka-ainevarat. Vuorimiesyhdistys, Sarja B, 51, 11-12.
9. Bornhorst, T. & Nurmi, P. (1999) Personal communication 20/1/1999.

Name	***Mujesuo***				
GENETIC TYPE	Orogenic ‘mesothermal’.				
LOCATION					
Geological domain	Archaean	**Belt**	Kuhmo		
Map sheet	4412 11	**X coordinate**	7141500	**Y coordinate**	4455000
Municipality	Kuhmo				
Nearest town, access	35 km NW from Kuhmo. A sealed road across the area.				
MINING					
Exploration licence no.	5412/1.				
Present holder	Geological Survey of Finland (GTK).				
Status of development	Prospect.				
EXPLORATION					
Discovery	By GTK 1994 [1,2]: first indication was an auriferous sample from a glacial erratic boulder, provided by an amateur prospector; the deposit was detected by trenching and drilling by GTK.				
Exploration history	GTK [1]: bedrock mapping, trenching, diamond drilling.				
Drilling	GTK [1]: 5 diamond-drill holes.				
Exploration geologist(s) in charge					
	GTK: Erkki Luukkonen.				
ORE					
Major opaques	Pyrrhotite [1].				
GEOLOGY					
Major host rocks	Mafic metavolcanic rock [1]				
Geological setting	Located in the northern part of the Late-Archaean Kuhmo Greenstone Belt [1].				
METAMORPHISM					
Metamorphic grade	Upper-greenschist facies [1].				
STRUCTURAL SETTING					
Structural style	Ductile.				
Controlling structure	N-S trending mylonites which are late-D3 or D4 structures [1,2].				
Deformation history	At least, six deformation stages during the late Archaean and two deformation stages during the Palaeoproterozoic detected in the area; gold mineralisation is related to the Archaean late D3 and/or D4 stages [2].				
Veins	Auriferous quartz vein, generally 5-10 cm wide [1].				
TIMING	Late Archaean [2].				
GENETIC MODEL	Clearly epigenetic, “mesothermal” mineralisation with a distinct structural control [1].				

References

1. Pietikäinen, K. 1998. Personal communication 14/9/98.
2. Luukkonen, E., Pajunen, M. & Poutiainen, M. 1992. Kuhmo-Suomussalmen alueen arkeeisen kallioperän rakenne-evoluutio ja Au-aiheet. In: E. Ekdahl (ed.) Suomen kallioperän kehitys ja raaka-ainevarat. Vuorimiesyhdistys, Sarja B, 51, 11-12.

Name	***Pahkalampi***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Archaean **Belt** Suomussalmi
Map sheet	4513 09 **X coordinate** 7241300 **Y coordinate** 4479300
Municipality	Suomussalmi
Nearest town, access	52 km NE from Suomussalmi. 6 km from a sealed road, 1.5 km from a gravel road.
MINING	
Exploration licence no.	5232/1.
Present holder	Geological Survey of Finland (GTK).
Status of development	Prospect.
Resources	0.05 Mt at 5.5 ppm Au (lode Pahkalampi I) [3,4].
Lodes	Possibly, several lodes - the resource estimate only includes one lode [3,4].
EXPLORATION	
Discovery	By GTK: a tiny mineralised outcrop found during exploration for base metals at Moukkori. This led to extensive ground geophysical and till geochemical surveys in the region. The Pahkalampi deposit was detected by driling into a till geochemical anomaly [4].
Exploration history	GTK (1990-97) [2,3,4]: Geological mapping, ground magnetic, slingram, VLF-R, total intensity and IP survey, till geochemical survey, trenching, diamond and RC drilling.
Drilling	GTK: 34 diamond-drill holes, total 3804 m, and 8 RC holes, total 446 m [4].
Exploration geologist(s) in charge	GTK: Erkki Luukkonen.
ORE	
Siting of gold	Gold is intergrown with tellurides; gold and tellurides are commonly as inlusions in pyrite, pyrrhotite, quartz, albite and K feldspar. In addition, there are free gold grains with silicates [1,5].
Fineness	53-92% Au, 0-46% Ag [1].
Major opaques	Pyrrhotite [1].
Minor opaques	Pyrite, ilmenite, cobaltite, chalcopyrite, sphalerite, volynskite, hessite, petzite, frohbergite, calaverite, tellurobismuth, bismuth, loellingite, galena, gold, electrum [1,4].
Gangue	Quartz, scheelite, tourmaline, rutile, titanite [1,4].
Enriched elements	Au, Ag, As, B, Bi, S,Te, W [1,4].
GEOLOGY	
Major host rocks	Amphibolite [1,4].
Minor host rocks	Uralite-porphyrite, intermediate schist, tourmaline-bearing granitoid [4].
Geological setting	The deposit is in the Tormua Schist Belt which forms the NE part of the late Archaean Suomussalmi Greenstone Belt [4].
Intrusives	TTG granitoids, from 2739±8 Ma to 2697±10 Ma of age, are abundant within and near the greenstone belt [4].
METAMORPHISM	
Metamorphic grade	Amphibolite facies, at about 5 kbar and 600°C [4].
STRUCTURAL SETTING	
Structural style	Brittle-ductile [4].
Controlling structure	A second-order D3 structure [3,4,5].
Deformation history	At least, four deformation stages during the late Archaean and two deformation stages during the Palaeoproterozoic time detected in the area; gold mineralisation is related to the Archaean late D3 stage [3,4,5].
Veins	Abundant quartz veins [1,4].
ALTERATION	
General alteration	Sericitisation and epidotisation [4].
Proximal alteration	Amphibolite: plagioclase-hornblende-quartz-epidote-titanite [1]. Intermediate schist: K feldspar-albite-quartz-biotite-titanite-scheelite [1].
TIMING	Late Archaean [5].
GENETIC MODEL	Orogenic “mesothermal” deposit, formed during D3 deformation at peak-metamorphic 5 kbar and 600°C or under slightly lower temperature [4].

References

1. Kojonen, K., Pakkanen, L. & Johanson, B. 1996. Kullan esiintyminen Suomussalmen Pahkalammen kultamalmiaiheessa. Geological Survey of Finland, unpublished report M42.4/4513/-96/1. 5 p. (in Finnish)
2. Pietikäinen, K. 1998. Personal communication 14/9/1998.
3. Ministry of Industry and Trade 1998. International tender notice. Tormua gold prospect, Suomussalmi, Finland. Press release 6/10/1998.
4. Luukkonen, E., Heino, T., Tenhola, M., Niskanen, M. & Hartikainen, A. 1997. Tutkimustyöselostus Suomussalmen kunnassa valtausalueella Saarilampi 1 (kaivosrekisteri 5351/1), Housuvaara 1-2 (kaivosrekisteri 4876/1-2), Mullikko 1 (kaivosrekisteri 5029/1), Pahka 1 (kaivosrekisteri 5029/2/1) ja Pahkalampi 1 (kaivosrekisteri 5232/1) suoritetuista kultamalmitutkimuksista vuosina 1990-1997. Geological Survey of Finland, unpublished report. 21 p. (in Finnish)
5. Luukkonen, E., Pajunen, M. & Poutiainen, M. 1992. Kuhmo-Suomussalmen alueen arkeeisen kallioperän rakenne-evoluutio ja Au-aiheet. In: E. Ekdahl (ed.) Suomen kallioperän kehitys ja raaka-ainevarat. Vuorimiesyhdistys, Sarja B, 51, 11-12.

Name	***Palovaara***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Archaean **Belt** Kuhmo
Map sheet	4412 12 **X coordinate** 7153000 **Y coordinate** 4455600
Municipality	Hyrynsalmi
Nearest town, access	45 km NW from Kuhmo. 1 km from a sealed road, a gravel road adjacent to the area.
MINING	
Exploration licence no.	4351/1-3.
Present holder	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	0.45 m at 4.6 ppm Au, 0.5 m at 3.1 ppm Au [2].
EXPLORATION	
Discovery	By GTK on 1987: auriferous, sulphide-bearing BIF units detected during zinc exploration in the area [2].
Exploration history	GTK (1988-1993) [2]: bedrock mapping, trenching, till geochemical survey, ground magnetic, electromagnetic, IP and VLF survey.
Drilling	GTK (1989-1993) 16 diamond-drill holes, total 1094 m [2].
Exploration geologist(s) in charge	
	GTK: Timo Heino.
GEOLOGY	
Major host rocks	BIF [1].
Minor host rocks	Intermediate metavolcanic rock [1]
Geological setting	The deposit is in a 10 km long BIF-intermediate metavolcanic rock sequence in the northern part of the Late-Archaean Kuhmo Greenstone belt [1,2].
Intrusives	An synorogenic tonalite is to the east of the mineralisation.
STRUCTURAL SETTING	
Controlling structure	Late D3 or D4 structures [3].
Deformation history	At least, six deformation stages during the late Archaean and two deformation stages during the Palaeoproterozoic detected in the area; gold mineralisation is related to the Archaean late D3 and/or D4 stages [3].
TIMING	Late Archaean [3].
GENETIC MODEL	Orogenic “mesothermal” deposit.

References

1. Pietikäinen, K. 1998. Personal communication 14/9/98.
2. Heino, T. 1995. Raportti valtausalueilla Palo 1-3, kaivosrekisterinumerot 4351/1, 4351/2 ja 4351/3, vuosina 1988-1993 suoritetuista tutkimuksista. Geological Survey of Finland, unpublished report M06/4412/-95/1/10. 8 p. (in Finnish)
3. Luukkonen, E., Pajunen, M. & Poutiainen, M. 1992. Kuhmo-Suomussalmen alueen arkeeisen kallioperän rakenne-evoluutio ja Au-aiheet. In: E. Ekdahl (ed.) Suomen kallioperän kehitys ja raaka-ainevarat. Vuorimiesyhdistys, Sarja. B, 51, 11-12.

Name	***Sepponen***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Archaean **Belt** Kuhmo
Map sheet	4324 08 **X coordinate** 7083900 **Y coordinate** 4488950
Municipality	Kuhmo
Nearest town, access	32 km SSE from Kuhmo, 45 km NE from Nurmes. 4 km to a sealed road, a gravel road to the area.
MINING	
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	Several ppm Au per metre in channel sampling on outcrop [2].
EXPLORATION	
Discovery	By GTK 1992: First indications were the auriferous glacial erratic boulders detected during regional till geochemical survey; this led to the discovery of the mineralisation in outcrop [2].
Exploration history	GTK [1,2]: Detailed bedrock mapping, trenching, ground IP survey.
Exploration geologist(s) in charge	
	GTK: Timo Heino.
ORE	
Siting of gold	Gold is associated with arsenopyrite [2].
Major opaques	Arsenopyrite, pyrrhotite [2].
Gangue	Quartz, hornblende, K feldspar, calcite [1,2].
GEOLOGY	
Major host rocks	Amphibolite [1,2].
Geological setting	A sequence of banded amphibolites and mica gneisses within a granitoid-dominated area, to the SE of the main area of the Late-Archaean Kuhmo Greenstone belt [1].
METAMORPHISM	
Metamorphic grade	Amphibolite facies [2].
Metamorphic mineral assemblage	Amphibolite: hornblende-plagioclase [2].
STRUCTURAL SETTING	
Structural style	Ductile [2].
Controlling structure	An Archaean D4, strike-oblique-slip, NW-trending, dextral shear and fault zone [1,2,3].
Deformation history	At least, six deformation stages during the late Archaean and two deformation stages during the Palaeoproterozoic time detected in the area; gold mineralisation is related to the Archaean D4 stage [1,2,3].
Veins	Auriferous quartz ± K feldspar, calcite, hornblende veins [1,2].
ALTERATION	
General alteration	Biotitisation, sulphidation [2].
Proximal alteration	Hornblende selvages, 1-3 cm wide, on the mineralisation-related quartz veins [2].
TIMING	Late Archaean [3].
GENETIC MODEL	Orogenic “mesothermal” deposit.

References

1. Luukkonen, E. 1993. Kultamineralisaatio Suomussalmen ja Kuhmon vihreäkivivyöhykkeellä. In: P. Nurmi (ed.) Itä-Suomen kultaesiintymät. Ekskursio-opas. Vuorimiesyhdistys, Sarja B, no. 54, 33-35. (in Finnish)
2. Pietikäinen, K. 1998. Personal communication 14/9/1998.
3. Luukkonen, E., Pajunen, M. & Poutiainen, M. 1992. Kuhmo-Suomussalmen alueen arkeeisen kallioperän rakenne-evoluutio ja Au-aiheet. In: E. Ekdahl (ed.) Suomen kallioperän kehitys ja raaka-ainevarat. Vuorimiesyhdistys, Sarja B, 51, 11-12.

Name	***Syrjälä***				
GENETIC TYPE	Orogenic ‘mesothermal’.				
LOCATION					
Geological domain	Archaean	**Belt**	Suomussalmi		
Map sheet	4511 10	**X coordinate**	7227500	**Y coordinate**	4455500
Municipality	Suomussalmi				
Nearest town, access	27 km N from Suomussalmi. 5 km from the sealed highway 5, a gravel road to the area.				
MINING					
Present holder	Geological Survey of Finland (GTK).				
Status of development	Prospect.				
Extent of mineralisation	A few metres to 15-20 m wide, open at depth of 100 m [1].				
Lodes	Two lodes [1].				
EXPLORATION					
Discovery	By GTK on 1994: first indications were a regional Au anomaly in till and an auriferous sample from a glacial erratic boulder, provided by an amateur prospector; the deposit was detected by drilling by GTK [1].				
Exploration history	GTK [1]: Bedrock mapping, till geochemical survey, diamond drilling, magnetic, electric and IP ground survey.				
Exploration geologist(s) in charge					
	GTK: Erkki Luukkonen, Kimmo Pietikäinen.				
GEOLOGY					
Major host rocks	Mafic to intermediate metavolcanic rocks [1].				
Geological setting	The mineralisation is in the western part of the late Archaean Suomussalmi greenstone belt [1].				
STRUCTURAL SETTING					
Controlling structure	NW-trending shear zones [1].				
Deformation history	At least, six deformation stages during the late Archaean and two deformation stages during the Palaeoproterozoic detected in the area; gold mineralisation is related to the Archaean late D3 and/or D4 stages [2].				
TIMING	Late Archaean [2].				
GENETIC MODEL	Orogenic “mesothermal” deposit.				

References

1. Pietikäinen, K. 1998. Personal communication 14/9/98.
2. Luukkonen, E., Pajunen, M. & Poutiainen, M. 1992. Kuhmo-Suomussalmen alueen arkeeisen kallioperän rakenne-evoluutio ja Au-aiheet. In: E. Ekdahl (ed.) Suomen kallioperän kehitys ja raaka-ainevarat. Vuorimiesyhdistys, Sarja B, 51, 11-12.

Name	***Mäkärärova (Siikalehto-1)***				
GENETIC TYPE	Orogenic 'mesothermal' ?				
LOCATION					
Geological domain	Archaean	**Belt**	Pomokaira Basement Complex		
Map sheet	3724 11	**X coordinate**	7567600	**Y coordinate**	3494400
Municipality	Sodankylä				
Nearest town, access	85 km N from Sodankylä. Highway 4 is 15 km from the area, a gravel road from the highway to the area.				
MINING					
Exploration licence no.	3031/1, 5843/4.				
Present holder	Conroy Plc.				
Previous holders	Geological Survey of Finland (GTK) (1950-1955, 1978-1985), Suomen Malmi Oy (1956-1957).				
Status of development	Prospect.				
Resources	0.08 Mt at 2.1 ppm Au [4].				
Total in-situ gold	168 kg [4].				
Best sections	3 m at 2.2 ppm Au, 1.2 m at 1 ppm Au, 0.75 m at 7 ppm Au [3].				
Extent of mineralisation	Maximum thickness of a mineralised vein is 2 m [2,3]. The extent of the vein swarm on the present surface is >0.5 km by >3 km [1].				
Lodes	Essentially, the lodes are formed by the veins [3].				
EXPLORATION					
Discovery	1949 by Mr Holger Jalander [1,3].				
Exploration history	H. Jalander and other entrepreneurs 1949-1950 [3]: Glacial erratic boulder survey, bedrock mapping, ground magnetic survey.				
	GTK 1950-1955 [3]: Ground magnetic survey, bedrock mapping, trenching, diamond drilling.				
	Suomen Malmi 1956-1957 [3]: Diamond drilling, pilot mining in small scale.				
	GTK 1978-1985 [1,2,3]: Till geochemistry and stratigraphy, bedrock mapping, till geochemical survey, high-altitude airborne gravimetric, magnetic, electromagnetic and radiometric survey, ground IP, magnetic and electromagnetic survey, diamond drilling.				
Drilling	GTK 1950-1955 [3]: Two diamond-drill holes.				
	Suomen Malmi 1956-1957 [3]: Eleven diamond-drill holes.				
	GTK 1983-1984 [2,3]: Four diamond-drill holes, total 808 m.				
Elements analysed	[1,3]: a set of 35 elements by ICP; Au by AAS and GFAAS.				
Geophysical response	No significant response on gravimetric, magnetic or electromagnetic methods [3]. An ground-IP anomaly around the major veins [1].				
Exploration geologist(s) in charge					
	GTK: Osmo Auranen, Ilkka Härkönen.				
ORE					
Siting of gold	Chiefly native gold in the veins, associated with pyrite; minor volumes of gold in the most intensely altered wallrock [1,2,3].				
Major opaques	Haematite [1,2,3].				
Minor opaques	Pyrite, gold [1,2,3].				
Gangue	Quartz-carbonate veins [1,2,3].				
Ore composition	Diamond-drill core, chiefly vein material [4]: 1.76 ppm Au, 0.089 ppm Ag, 3.8 ppm As, 42 ppm B, 242 ppm Ba, 1.6 ppm Bi, 103 ppm Co, 7.4 ppm Cu, 22.0 ppb Hg, 5 ppm Mo, 116 ppm Ni, <2 ppm Pb, 95 ppm Rb, 18100 ppm S, 0.2 ppm Sb, 0.46 ppm Se, 10 ppm Sr, 1.75 ppm Te, 4.9 ppm Th, 1.9 ppm U, 86 ppm V, 15 ppm W, 39 ppm Zn, 187 ppm Zr; 53.7% SiO_2, 0.50% TiO_2, 6.76% Al_2O_3, 32.2% Fe_2O_3, 0.53% MgO, 0.10% CaO, 0.08% Na_2O3, 2.40% K_2O, 0.16% P_2O_5, 3.93% LOI.				
Enriched elements	Au, Fe, S, Te, W [4].				
GEOLOGY					
Major host rocks	Banded granitoid gneiss [1,2,3].				
Minor host rocks	Banded hornblende and arkose gneisses [2,3].				
Geological setting	The mineralisation is in the Pomokaira Basement Complex, which is an about 2.9-3.1 Ga, high-metamorphic grade, domain consisting of ortho(?)- and paragneisses [2,3,5].				
Intrusives	Pre-veining and -mineralisation pegmatites in the gneiss [2,3].				
METAMORPHISM					
Metamorphic grade	Upper-amphibolite or lower-granulite facies [2,3].				
Metamorphic mineral assemblage	Hornblende-quartz-K feldspar-plagioclase-biotite±garnet [1].				
STRUCTURAL SETTING					
Structural style	Brittle-ductile? [1,2,3].				

Closest major shear	A NW-trending shear zone, at least several tens of kilometres long, <0.5-1 km east from the mineralisation [1,2,3].
Controlling structure	Diagonal tensional fractures of the NW-trending major shear zone [1,2,3].
Veins	Quartz-haematite-carbonate-pyrite veins, 1 mm - 2 m in thickness, which are vertical or dip steeply to the SW [1,2,3].
ALTERATION	
General alteration	Formation of the mineral assemblage quartz-sericite-chlorite (no zoning described) [1,2,3]. The extent of alteration is up to 5 m from single veins [1,3].
GENETIC MODEL	Orogenic “mesothermal” deposit. Au possibly transported as chloride complex.
FIGURES	[1]: Local geology map. [3]: Location of the veins, drill holes and excavated trenches. [5]: Regional geology map.

References

1. Rahkola, P. 1982. Raportti Mäkärärovan ja Kiviaavan tutkimuksista. Geological Survey of Finland, unpublished report S/41/3724/1/1982. 26 p. (in Finnish)
2. Härkönen, I. 1985. Tutkimustyöselostus Sodankylän kunnassa valtausalueella Siikalehto 1, kaiv.rek. n:o 3031/1 suoritetuista malmitutkimuksista. Geological Survey of Finland, unpublished report M06/3724/-85/1/10. 4 p. (in Finnish)
3. Härkönen, I. 1987. Kultatutkimukset Mäkärärovan alueella Sodankylässä vuosina 1980-1985. Geological Survey of Finland, unpublished report M19/3724/-87/1/10. 18 p. (in Finnish)
4. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland Bulletin 351. 101 p.
5. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.

Name	***Ahvenjärvi (Isomaa)***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kittilä
Map sheet	2734 05 **X coordinate** 7503870 **Y coordinate** 2553600
Municipality	Kittilä
Nearest town, access	15 km E from Kittilä. One km from a sealed road, a gravel road to the area.
MINING	
Exploration licence no.	4867/1, 5699/1.
Present holder	Geological Survey of Finland (GTK).
Previous holders	Outokumpu Oy (-1994).
Status of development	Prospect.
Best sections	1 m at 4.9 ppm Au, 1 m at 3.8 ppm Au, 5 m at 1.3 ppm Au [2].
Extent of mineralisation	A few metres wide, >100 m long domain comprising a set of parallel mineralised zones [2].
EXPLORATION	
Discovery	A mineralised outcrop detected on 1984 by GTK during regional bedrock mapping [2].
Exploration history	Outokumpu (in a small part of the area; -1994) [3]: till geochemical and stratigraphy survey GTK (in the area since 1984-) [2]: bedrock mapping, trenching, RC and diamond drilling, till geochemical and stratigraphy survey, airborne low-altitude magnetic, elecromagnetic, radiometric and gravity survey.
Secondary dispersion	Au anomalies in till in the area [2,3].
Exploration geologist(s) in charge	Outokumpu: Erkki Ilvonen; GTK: Veikko Keinänen.
ORE	
Major opaques	Pyrite [2].
Minor opaques	Gold, Au-Ag tellurides, molybdenite [2].
Gangue	Quartz, tourmaline [2].
Enriched elements	Au, Ag, B, K, Mo, S, Te [2].
GEOLOGY	
Major host rocks	Quartzite [2].
Minor host rocks	Metasiltstone [2].
Geological setting	The host rocks are part of the volcano-metasedimentary sequence of the Virttiövaara Formation of the >2210 Ma Sodankylä Group of the Palaeoproterozoic Central Lapland Greenstone Belt [1].
METAMORPHISM	
Metamorphic grade	Greenschist facies [2].
STRUCTURAL SETTING	
Structural style	Brittle [2].
Closest major shear	A WSW-trending major thrust, the Sirkka Line, about 3 km south of the mineralisation [1].
Veins	WNW-trending, auriferous quartz-tourmaline ± pyrite veins brecciate the host rock [2].
ALTERATION	
Proximal alteration	Intense sericitisation [2].
Distal alteration	Albitisation [2].
GENETIC MODEL	Clearly epigenetic, “mesothermal” mineralisation with a distinct structural control [2].
FIGURES	[1]: Regional geology map.

References

1. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
2. Keinänen, V. 1998. Personal communications on 20/8/1998 and 23/12/1998.
3. Ilvonen, E. 1994. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Kittilä, Ahvenjärvi. Outokumpu Oy, unpublished report 080/2734 05/ EI/94. 2 p. (in Finnish)

Name	***Hirvasselkä***				
GENETIC TYPE	Orogenic ‘mesothermal’?				
LOCATION					
Geological domain	Lapland	**Belt**	Lapland Granulite Complex		
Map sheet	3831 04	**X coordinate**	7584350	**Y coordinate**	3510900
Municipality	Inari				
Nearest town, access	36 km south from Ivalo. 3 km from the sealed Highway 4, 1.5 km from a gravel road.				
MINING					
Exploration licence no.	3211/1.				
Present holder	OPEN FOR ACQUISITION.				
Previous holders	Rautaruukki Oy (1981-1984).				
Status of development	Prospect.				
Best sections	Highest contents: 4.4 ppm Au, 7.3 ppm Au, 12.4% Ba - extent not given [1].				
Extent of mineralisation	A 3-7 m wide zone of veining and mineralisation [1].				
EXPLORATION					
Exploration history	Rautaruukki Oy (1981-1984) [1]: survey of glacial erratic boulders, bedrock mapping, trenching, ground magnetic survey, diamond drilling.				
Drilling	Rautaruukki Oy (1981-1982) [1]: two diamond-drill holes, total 63 m.				
Elements analysed	Au, Ag, Ba, Cu, S [1].				
Exploration geologist(s) in charge					
	Rautaruukki: Kari Airas.				
ORE					
Major opaques	Haematite [1].				
Minor opaques	Gold [1].				
Gangue	Quartz, baryte [1].				
Ore composition	5.8 ppm Au, 1.0 ppm Ag, 400 ppm Ba, 20 ppm Cu [1].				
GEOLOGY					
Major host rocks	Intermediate metavolcanic rock [1].				
Minor host rocks	Quartz-feldspar gneiss (felsic metavolcanic rock), granulite [1].				
Geological setting	The vein mineralisation is in a volcano-sedimentary sequence within the Lapland Granulite Complex [1].				
METAMORPHISM					
Metamorphic grade	Lower-granulite facies? [1].				
STRUCTURAL SETTING					
Veins	Quartz-haematite-baryte veins [1].				
GENETIC MODEL	Orogenic “mesothermal” mineralisation?				
FIGURES	[2]: Regional geology map.				

References

1. Airas, K. 1984. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Inari, Hirvasselkä 1, kaiv. rek. n:o 3211/1. Lapin Malmi Oy, unpublished report 080/3831/KA/84/6. 1 p . (in Finnish)
2. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.

Name	***Hirvilavanmaa***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kittilä
Map sheet	2734 06 **X coordinate** 7518400 **Y coordinate** 2550100
Municipality	Kittilä
Nearest town, access	15 km NE from Kittilä. 5 km from a sealed road, 2 km from a gravel road.
MINING	
Exploration licence no.	6095/1.
Present holder	Terra Mining (1996-).
Previous holders	Geological Survey of Finland (GTK) (1977-1996).
Status of development	Prospect.
Best sections	3.5 m at 6.5 ppm Au, 28 m at 5.2 ppm Au [5].
EXPLORATION	
Discovery	By the GTK on 1980’s [5].
Exploration history	Atri Oy in the late 1940’s [3]: Bedrock mapping, ground magnetic and electromagnetic survey. GTK 1977-1996 [1,3,6,7,8,10,11]: High- and low-altitude airborne magnetic, electromagnetic, gravimetric and radiometric survey, ground magnetic, gravimetric, slingram, VLF-R, SIP (= spectral IP) and normal IP survey, regional and local till stratigraphy and geochemistry, stream sediment geochemical survey, bedrock mapping, trenching, diamond drilling, systematic percussion drilling into bedrock surface, detailed mineralogical studies.
Drilling	GTK 1977-1996: diamond and RC drilling [5].
Elements analysed	By GFAAS: Ag, Au, Co, Cu, Mo, Ni, Pb, Te, Zn, by fire assay: Au, by ICP: Ag, Al, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Sc, Si, Sr, Th, Ti, V, Y, Zn [9].
Economic evaluations	Apparently, by Terra Mining during 1997-1998.
Geophysical response	A non-magnetic domain within a positive magnetic anomaly [5]. The SIP method indicates the areas of altered rock [10].
Secondary dispersion	Regional As, Co, Cu and Mo anomalies in till cover the area [3,5,6]. Local Au, Co, Cu, Mo and W anomaly in till [3,5,6].
Exploration geologist(s) in charge	GTK: Veikko Keinänen; Terra Mining: Markku Kilpelä.
ORE	
Siting of gold	Native gold occurs associated with pyrite and tellurides [3,5].
Major opaques	Pyrite [1].
Minor opaques	Chalcopyrite, rutile, magnetite, haematite, chromite, tetrahedrite, gold, Ag-Au tellurides, galena, silver [1,5,7,11].
Gangue	Quartz, Fe dolomite, magnesite, monazite, Y-phosphate [1,3,5,6,11].
Ore composition	Diamond-drill core, metakomatiite [9]: 0.560 ppm Au, 0.174 ppm Ag, 1.8 ppm As, 29.4 ppm B, 115 ppm Ba, <0.1 ppm Bi, 51 ppm Co, 29 ppm Cu, <5 ppb Hg, 3 ppm Mo, 802 ppm Ni, <2 ppm Pb, 8 ppm Rb, 4060 ppm S, 5.9 ppm Sb, 0.04 ppm Se, 44 ppm Sr, 0.250 ppm Te, <0.5 ppm Th, <0.1 ppm U, 160 ppm V, 2 ppm W, 65 ppm Zn, 29 ppm Zr; 35.4% SiO_2, 0.55% TiO_2, 5.12% Al_2O_3, 9.71% Fe_2O_3, 17.8% MgO, 5.44% CaO, 1.19% Na_2O, 0.03% K_2O, 0.032% P_2O_5, 22.9% LOI.
Enriched elements	Au, CO_2, (Na), S, Sb, Te [9].
GEOLOGY	
Major host rocks	Metakomatiite [1].
Geological setting	The komatiitic host rocks are in a sequence of basaltic and komatiitic metavolcanic rocks and fine-grained metasedimentary rocks of the >2050 Ma Savukoski Group of the Palaeoproterozoic Central Lapland Greenstone Belt [4].
METAMORPHISM	
Metamorphic history	Regional metamorphism took place at ca. 1.9 Ga [8].
Metamorphic grade	Lower- or mid greenschist facies [8].
Metamorphic mineral assemblage	Ultramafic rocks: talc-chlorite-calcite [5].
STRUCTURAL SETTING	
Structural style	Brittle(-ductile).
Closest major shear	More than 150 km long, E-W to NW-SE trending shear zone, the Sirkka Line [3,7].
Controlling structure	The deposit is in the eastern flank of the Sirkka Line which here has a NW-SE trend [7].
Ore fabric	Granoblastic [3,11].
Veins	Quartz-dolomite-albite-pyrite [5].
ALTERATION	
General alteration	Synvolcanic and/or early-metamorphic, pre-gold albitisation and partial carbonation of large areas was followed by synorogenic, structurally-controlled carbonation and sericitisation with gold mineralisation [3,7].

Proximal alteration	Quartz-Fe dolomite-magnesite-pyrite-albite-rutile ± talc, chlorite, magnetite+chromite [5,11].
Intermediate alteration	Talc-chlorite-Fe dolomite-magnesite-albite-pyrite-magnetite-chromite-rutile [5,11].
Distal alteration	Talc-chlorite-dolomite-magnesite-magnetite-chromite-rutile [5].
TIMING	The gold mineralisation in the Kuotko-Kiistala-Soretiavuoma area, which includes the Hirvilavanmaa mineralisation, probably took place between 1852-1890 Ma [2].
GENETIC MODEL	Clearly epigenetic, "mesothermal" mineralisation with a distinct structural control [5,7,8,9].
FIGURES	[4]: Regional geology map.

References

1. Härkönen, I. & Keinänen, V. 1989. Exploration of structurally controlled gold deposits in the Central Lapland greenstone belt. Current Research 1988, Geological Survey of Finland, Special Paper 10, 79-82.
2. Mänttäri, I. 1995. Lead isotope characteristics of epigenetic gold mineralization in the Palaeoproterozoic Lapland greenstone belt, northern Finland. Geological Survey of Finland, Bulletin 381. 70 p.
3. Keinänen, V., Johansson, P. & Lehmuspelto, P. 1988. Soretiavuoman volframi- ja kultatutkimuksista. Annales Universitatis Turkuensis, Sarja C, Tom 67, 69-77. (in Finnish)
4. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
5. Keinänen, V. 1997, 1998. Personal communications on 24/11/1997, 18/8/1998 and 23/12/1998.
6. Johansson, P., Keinänen, V. & Lehmuspelto, P. 1986. Geochemical exploration of tungsten in glaciogenic deposits in Soretiapulju, western Finnish Lapland. Proceedings in Areas of Glaciated Terrain. Symposium held in Kuopio, 1 and 2 September 1986. London: The Institution of Mining and Metallurgy, 61-67.
7. Keinänen, V. & Hulkki, H. 1992. Main features of the three geochemically different gold mineralizations in Soretiavuoma, Finnish Lapland. 20:e Nordiska Geologiska Vintermötet, Reykjavik. Abstracts. p. 96.
8. Keinänen, V. 1994. Shear zone-related Soretialehto gold occurrence in green carbonate rocks in the Central Lapland Greenstone Belt, Kittilä, Finnish Lapland. 21:a Nordiska Geologiska vintermötet, Luleå. Abstracts. p. 99.
9. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of. Finland, Bulletin 351. 101 p.
10. Vanhala, H. 1997. Laboratory and field studies of environmental and exploration applications of the spectral induced-polarization (SIP) method. Geological Survey of Finland. 104 p.
11. Riikonen, S. 1997. Kittilän kromimarmorien mineralogia. Unpublished MSc thesis, Department of Geology, University of Oulu. 61 p. (in Finnish)

Name	***Hookana***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Sodankylä
Map sheet	3714 04 **X coordinate** 7499725 **Y coordinate** 3476825
Municipality	Sodankylä
Nearest town, access	20 km NW from Sodankylä. A sealed road across to the area.
MINING	
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK) (1986-1987).
Status of development	Prospect.
Best sections	1 m at 1 ppm Au [3].
EXPLORATION	
Discovery	By GTK on1986: during regional geochemical exploration program, auriferous boulders led to the mineralised outcrops [3].
Exploration history	GTK (1986-1987) [1,3]: regional and detailed till geochemistry and stratigraphy, sampling from bedrock surface below the overburden by percussion drilling, detailed outcrop mapping, trenching, low-altitude airborne gravimetric, magnetic, electromagnetic and radiometric survey; systematic ground magnetic and slingram survey.
Geophysical response	Response on slingram [3].
Exploration geologist(s) in charge	
	GTK: Eelis Pulkkinen.
ORE	
Major opaques	Pyrite, chalcopyrite [1,3].
Minor opaques	Pyrrhotite, gold [1].
Gangue	Quartz, tourmaline [1].
Enriched elements	Ag, Au, B, Co, CO_2, Cu, S [1].
GEOLOGY	
Major host rocks	Albitised dolerite [1,3].
Minor host rocks	Albitised intermediate tuff and/or metasedimentary rock [1,3].
Geological setting	The tuffs or metasedimentary rocks are part of the Matarakoski Formation of the >2050 Ma Savukoski Group of the Palaeoproterozoic Central Lapland Greenstone Belt [2].
Intrusives	Pre-gold mineralisation dolerite [1].
METAMORPHISM	
Metamorphic grade	Mid- or upper greenschist facies, according to mineral assemblages (biotite present).
Metamorphic mineral assemblage	Dolerite: albite-actinolite-epidote [3].
STRUCTURAL SETTING	
Structural style	Brittle [3].
Ore fabric	Granoblastic, brecciated [3].
ALTERATION	
General alteration	The domain of albitised and carbonated rocks is 1-2 km wide and 15 km long [1].
Proximal alteration	Biotite-quartz-carbonate ± pyrite [1,3].
GENETIC MODEL	Orogenic “mesothermal” deposit.
FIGURES	[2]: Regional geology map.

References

1. Pulkkinen, E., Ollila, J., Manner, R. & Koljonen, T. 1986. Geochemical exploration for gold in the Sattasvaara komatiite complex, Finnish Lapland. In: Prospecting in areas of glaciated terrain 1986: papers presented at the Seventh International Symposium organised by the Institution of Mining and Metallurgy and the Geological Survey of Finland, Kuopio, 1-2 September, 1986. London: The Institution of Mining and Metallurgy, 129-137.
2. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
3. Pulkkinen, E. 1998. Personal communication 21/08/1998.

Name	***Kaaresselkä***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Lapland **Belt** Sodankylä
Map sheet	3714 01 **X coordinate** 7492637 **Y coordinate** 3466390
Municipality	Sodankylä
Nearest town, access	20 km NW from Sodankylä. 11 km from a sealed road, a gravel road to the area.
MINING	
Present holder	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	2 m at 45 ppm Au, several 3 m sections at >10 ppm Au, several 1-2 m sections at 1-2 ppm Au [1,3].
Extent of mineralisation	The lodes are in a NW trending, 200-1000 m wide, >4 km long domain, which is open to the NW and SE and in depth [1,3].
Lodes	At least six shear zone-hosted, parallel lodes [1,3].
EXPLORATION	
Discovery	By GTK (1987) [3]: First indications were outcrop samples containing 0.1-0.3 ppm Au found during base-metal exploration. The mineralisation was finally detected (1 m at 15 ppm Au) when diamond-drilled into a weathered bedrock-surface Au anomaly.
Exploration history	GTK (1997-) [1,3]: Trenching, bedrock mapping, till geochemical survey, percussion drilling into bedrock surface through overburden, diamond drilling, ground magnetic, IP, SP and slingram survey.
Secondary dispersion	A weak regional and a stronger local Au anomaly in till [3].
Exploration geologist(s) in charge	GTK: Eelis Pulkkinen.
ORE	
Major opaques	Pyrite [1,3].
Minor opaques	Chalcopyrite [3].
Gangue	Quartz, Fe dolomite/ankerite [3].
GEOLOGY	
Major host rocks	Albitised intermediate tuff and/or metasedimentary rock [1,3].
Minor host rocks	Dolerite, metakomatiite, metaconglomerate, quartzite [1,3].
Geological setting	The host and wall rocks are, apparently, part of the volcano-metasedimentary sequence of the Honkavaara Formation of the >2210 Ma Sodankylä Group of the Palaeoproterozoic Central Lapland Greenstone Belt [2].
Intrusives	Dolerites which predate gold mineralisation [1,3].
METAMORPHISM	
Metamorphic grade	According to mineral assemblages present [1,3], mid- or upper-greenschist facies.
Metamorphic mineral assemblage	Dolerite: albite-actinolite-epidote-titanite [1].
STRUCTURAL SETTING	
Structural style	Brittle-ductile [1].
Closest major shear	The Sirkka Line, which here has a WNW-trend, is <1 km S from the mineralisation [2].
Controlling structure	A set of E-W trending, subconformable(?) shear zones [1] which may be subsidiary shear or fault zonesof the Sirkka Line.
Veins	Quartz-carbonate ± pyrite, tourmaline [1,3].
ALTERATION	
General alteration	Early, pre-gold(?) albitisation and chloritisation (synvolcanic and/or early-metamorphic), and gold-related chloritisation, carbonation, sericitisation and sulphidation [1,3]. In addition, minor biotitisation and formation tourmaline and adularia [3].
Proximal alteration	Metakomatiite: carbonate-talc(?)-chlorite-biotite [1].
	Tuffite/metasedimentary. rock: quartz-sericite-pyrite [3].
Distal alteration	Metakomatiite: talc-chlorite-carbonate(?) [1].
GENETIC MODEL	Orogenic "mesothermal" deposit.
FIGURES	[2]: Regional geology map.

References

1. Pulkkinen, E. 1998. Personal communication 21/8/1998.
2. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
3. Pulkkinen, E. 1998. Sodankylän Kaaresselän kultaesiintymät. In: Proterotsooisten nikkeli- ja kultamalmien etsintä sekä orogeniavyöhykkeiden tektonomagmaattinen kehitys. Geological Survey of Finland, Excursion Guide 15-18.9.1998. (in Finnish)

Name	***Kittilän Hanhilampi (Jolhikko)***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kittilä
Map sheet	2732 09 **X coordinate** 7512580 **Y coordinate** 2528800
Municipality	Kittilä
Nearest town, access	12 km NW from Kittilä. 5 km from a sealed road, a gravel road to the area.
MINING	
Exploration licence no.	4481/1-2, 4516/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oy (1989-1991).
Status of development	Prospect.
Best sections	1 m at 13.3 ppm Au [2].
EXPLORATION	
Discovery	By Outokumpu on late 1980’s [2].
Exploration history	Outokumpu Oy 1989-1991 [2]: bedrock mapping, ground slingram and magnetic survey, trenching, diamond drilling, till geochemical survey.
Drilling	Outokumpu 1989-1990 [2]: three diamond-drill holes, total 222 m.
Elements analysed	Au, Cu [2].
Exploration geologist(s) in charge	
	Outokumpu: Rauno Hugg, Osmo Inkinen.
ORE	
Major opaques	Pyrite, pyrrhotite [2].
Gangue	Ankerite, quartz [2].
GEOLOGY	
Major host rocks	Metadolerite [2].
Minor host rocks	Mafic metalava [2].
Geological setting	The mineralisation is in a sequence of dominantly metavolcanic rocks of the >2050 Ma Savukoski Group of the Palaeoproterozoic Central Lapland Greenstone Belt [1].
Intrusives	The deposit is hosted by a dolerite apparently belonging to the 2.0 Ga age group (interpreted from [1,2]).
METAMORPHISM	
Metamorphic grade	Greenschist facies [2].
STRUCTURAL SETTING	
Structural style	Brittle.
Closest major shear	The Sirkka Line is 5 km to the nosrth of the mineralisation [1].
Controlling structure	An E-W trending shear or fault zone [1].
Veins	Fe carbonate ± quartz [2].
ALTERATION	
General alteration	Restricted, locally intense, carbonation of the host- and wallrocks [2].
GENETIC MODEL	Clearly epigenetic, “mesothermal” mineralisation with a distinct structural control [2].
FIGURES	[1]: Regional geology map.

References

1. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
2. Inkinen, O. 1991. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Kittilä, Hanhilampi 1, Hanhilampi 2 ja Hanhilampi 3, kaiv. rek. n:o 4481/1, 4481/2 ja 4516/1. Outokumpu Oy, unpublished report 080/2732/OI/91. 2 p. (in Finnish)

Name	***Koppelokangas (Rimplelä)***				
GENETIC TYPE	Orogenic ‘mesothermal’.				
LOCATION					
Geological domain	Lapland	**Belt**	Sodankylä		
Map sheet	3714 02	**X coordinate**	7503000	**Y coordinate**	3461000
Municipality	Sodankylä				
Nearest town, access	35 km NW of Sodankylä, 130 km N of Rovaniemi. 20 km from a sealed road, a gravel road to the area.				
MINING					
Exploration licence no.	4440/1.				
Present holder	OPEN FOR ACQUISITION.				
Previous holders	Geological Survey of Finland (GTK) (1985-1986), Outokumpu Oy (1989-1992).				
Status of development	Prospect.				
Best sections	2 m at about 1 ppm Au [1].				
EXPLORATION					
Discovery	By Outokumpu on 1989: Reanalysis of old drill core from the area [1].				
Exploration history	GTK 1985-1986 [3]: till geochemical survey, trenching, bedrock mapping.				
	Outokumpu 1989-1992 [1]: reanalysis of old drill core, diamond drilling.				
Drilling	Outokumpu 1989-1992 [1]: five diamond-drill holes, total 585 m.				
Elements analysed	Au [1].				
Exploration geologist(s) in charge					
	GTK: Eelis Pulkkinen; Outokumpu: Osmo Inkinen.				
ORE					
Major opaques	Pyrite [3].				
GEOLOGY					
Major host rocks	Albitised metasedimentary rocks [1,3].				
Minor host rocks	Black schist, mafic metavolcanic rocks [1].				
Geological setting	Mineralisation is in a sequence of metavolcanic and metasedimentary rocks [1,3] of the Matarakoski Formation of the >2050 Ma Savukoski Group of the Palaeoproterozoic Central Lapland Greenstone Belt [2].				
METAMORPHISM					
Metamorphic grade	Greenschist facies [1].				
STRUCTURAL SETTING					
Structural style	Brittle-ductile [1].				
GENETIC MODEL	Clearly epigenetic, “mesothermal” mineralisation with a distinct structural control [3].				
FIGURES	[1]: Location map, drilling sections. [2]: Regional geology map.				

References

1. Inkinen, O. 1992. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Sodankylä, Koppelonkangas, kaiv. rek. n:o 4440/1. Outokumpu Oy, unpublished report 080/3712/OI/92. 1 p. (in Finnish)
2. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
3. Pulkkinen, E. 1998. Personal communication 21/08/1998.

Name	***Kuotko (Iso-Kuotko)***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Lapland **Belt** Kittilä
Map sheet	2744 04 **X coordinate** 7550400 **Y coordinate** 2559100
Municipality	Kittilä
Nearest town, access	45 km NE from Kittilä, along road, 70 km NE from Kittilä. 24 km from a sealed road, 1 km from a gravel road.
MINING	
Exploration licence no.	4281/1-2, 4319, 4333/1-2, 4417/2, 6314/1.
Present holder	Municipality of Kittilä (1995-).
Previous holders	Geological Survey of Finland (GTK) (1987-95).
Status of development	Prospect.
Resources	Iso-Kuotko main lode: 0.08 Mt at 3.5 ppm Au (1993); 0.17 Mt at 4.3 ppm Au [7].
Total in-situ gold	725 kg Au [7].
Best sections	1.8 m at 17.4 ppm Au, 5.25 m at 7.35 ppm Au, 2.2 m at 8.84 ppm Au [2].
Lodes	A set of several parallel, NW-trending, subvertical lodes [2,3,7]. The main lode is, at surface, 15 m wideand 120 m long, and it is open at depth of 40 m [7].
EXPLORATION	
Discovery	GTK 1986 [2,7]: The area was selected for focussed exploration due to its favourable geophysical signature in airborne survey and due to a regional Au anomaly in till. Gold mineralisation was detected by percussion drilling through the overburden into bedrock surface.
Exploration history	GTK 1987-1994 [1,2,3,7]: High- and low-altitude airborne magnetic, electromagnetic, gravimetric and radiometric survey, ground magnetic, slingram, VLF-R, AMT, SP and IP survey, regional and local till stratigraphy and geochemistry, bedrock mapping, trenching, diamond drilling, systematic percussion drilling into bedrock surface.
Drilling	GTK 1988 and 1992 [2]: 11 diamond-drill holes, total 1323 m.
Elements analysed	Au and Pd by GFAAS, Ag, As, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb and Zn by ICP, and S by Leco [2]. By GFAAS: Ag, Au, Co, Cu, Mo, Ni, Pb, Te, Zn, by fire assay: Au, by ICP: Ag, Al, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Sc, Si, Sr, Th, Ti, V, Y, Zn [5].
Geophysical response	Strong response on ground IP and VLF-R by pyrite-rich rocks (by pyrite in both veins and as disseminated in the wallrocks) [2]. Weak response on low-altitude airborne electromagnetic methods [7].
Secondary dispersion	Au anomaly in till [7].
Exploration geologist(s) in charge	GTK: Ilkka Härkönen.
ORE	
Siting of gold	Chiefly native gold associated with the sulphides; the grain size of gold is up to 5 mm [1,2,3]. Of all gold, 60% as free native gold, 40% as native gold as submicroscopic inclusions in sulphides [7].
Major opaques	Arsenopyrite, pyrite, pyrrhotite [1,2,7].
Minor opaques	Chalcopyrite, galena, gold, native Bi, maldonite [1,2,7].
Gangue	Quartz, ankerite/dolomite [2].
Ore composition	Bulk ore: 4.3 ppm Au [7]. Arsenic content commonly 1-2% [2].
	Diamond-drill core [5]: 1.40 ppm Au, 0.693 ppm Ag, 11000 ppm As, 17.5 ppm B, 17 ppm Ba, 20 ppm Bi, 32 ppm Co, 211 ppm Cu, 47 ppb Hg, <1 ppm Mo, 44 ppm Ni, 12 ppm Pb, 62 ppm Rb, 24800 ppm S, 1.9 ppm Sb, 0.14 ppm Se, 84 ppm Sr, 0.160 ppm Te, 1.8 ppm Th, 0.9 ppm U, 320 ppm V, <0.5 ppm W, 128 ppm Zn, 175 ppm Zr; 32.8% SiO_2, 2.33% TiO_2, 8.63% Al_2O_3, 17.3% Fe_2O_3, 6.22% MgO, 8.07% CaO, 0.50% Na_2O, 2.26% K_2O, 0.41% P_2O_5, 18.8% LOI.
Enriched elements	Au, Ag, As, Bi, CO2, Hg, K, S, Te and W enriched, but no Sb enrichment and, apparently, Na depletion [5,7].
Pb isotope data	Pb-Pb age for pyrrhotite 1781 Ma, for galena 1805-1818 Ma, for pyrite 1889 Ma; the sulphides also define an Pb-Pb isochron age of 2103±85 Ma [6].
GEOLOGY	
Major host rocks	Mafic pyroclastic(?), Fe-tholeiitic rocks [7].
Geological setting	The mineralisation and the host rocks are within a sequence of mafic metavolcanic rocks and volcanogenic metasedimentary rocks [1,2] of the Kautoselkä Formation of the >2000 Ma Kittilä Group of the Palaeoproterozoic Central Lapland Greenstone Belt [4,7].
Intrusives	Felsic and lamprophyre dikes in the area, the former are mineralised and predate mineralisation while the latter post-date gold [1,7].
METAMORPHISM	
Metamorphic grade	Greenschist facies [1].

STRUCTURAL SETTING

Structural style	Brittle(-ductile) [1,7].
Closest major shear	A SW-NE trending, up to 1-2 km wide, major shear zone, the Kuotko Main Shear [1,7].
Controlling structure	The deposit is to the NW of the Kuotko Main Shear, in a minor shear branching from the latter [1,7].
Veins	Auriferous quartz-carbonate ± sulphides veins with thickness of up to several metres; post-mineralisation, barren, quartz veins [1,7].
ALTERATION	
General alteration	Carbonation, sericitisation, sulphidation [7].
TIMING	Pb-Pb age for pyrrhotite 1781 Ma, for galena 1805-1818 Ma, for pyrite 1889 Ma, the sulphides also define an Pb-Pb isochron age of 2103±85 Ma [6]. These suggest at least two stages of formation of sulphides in the area; the early isochron age cannot be related to gold mineralisation, as, for example, the felsic host rocks are probably related to granodiorites which have an U-Pb zircon age of 1915±7 Ma [6]. In summary, the gold mineralisation in the Kuotko-Kiistala-Soretiavuoma area apparently took place between 1852-1890 Ma [6].
GENETIC MODEL	Clearly epigenetic, “mesothermal” mineralisation with a distinct structural control [1,7].
FIGURES	[1]: Local bedrock map. [2]: Drill hole plan map. [4]: Regional geology map.

References

1. Härkönen, I. & Keinänen, V. 1989. Exploration of structurally controlled gold deposits in the Central Lapland greenstone belt. Current Research 1988, Geological Survey of Finland, Special Paper 10, 79-82.
2. Härkönen, I. 1994. Tutkimustyöselostus Kittilän kunnassa valtausalueilla Kuotko 3, kaiv.rek. n:o 4319, Kuotko 4, kaiv.rek. n:o 4333/1-2, ja Kuotko 5, kaiv.rek. n:o 4333/1-2, suoritetuista malmitutkimuksista. Geological Survey of Finland, unpublished report M06/2743/-95/1/10. 5 p. (in Finnish)
3. Härkönen, I. 1994. Tutkimustyöselostus Kittilän kunnassa valtausalueilla Kuotko 6 (kaiv. rek. N:o 4417/1) ja Kuotko 7 (kaiv. rek. N:o 4417/2) suoritetuista malmitutkimuksista. Geological Survey of Finland, unpublished report M06/2744,2743/-94/2/10. 4 p. (in Finnish)
4. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
5. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
6. Mänttäri, I. 1995. Lead isotope characteristics of epigenetic gold mineralization in the Palaeoproterozoic Lapland greenstone belt, northern Finland. Geological Survey of Finland Bulletin 381. 70 p.
7. Härkönen, I. 1998. Personal communication 24/8/1998 and 17/9/1998.

Name	***Kutuvuoma***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kittilä
Map sheet	3712 08 **X coordinate** 7501200 **Y coordinate** 3447000
Municipality	Kittilä
Nearest town, access	35 km ESE from Kittilä, 45 km NW from Sodankylä. 6 km from a sealed road, a gravel road to the area.
MINING	
Exploration licence no.	4843/1, 5468/1, 5813/1.
Present holder	Outokumpu Oyj (acquisition option for Terra Mining until 1/7/2000).
Status of development	Open pit.
When mined	1998-.
Resources	At least 0.025 Mt “high-grade ore” [2].
EXPLORATION	
Discovery	By Outokumpu: percussion drilling in an Au anomaly in till originally detected by the GTK [3].
Exploration history	GTK [3]: regional till geochemical survey. Outokumpu (-1998) [3]: till geochemical survey, bedrock mapping, ground geophysical survey, diamond, percussion and RC drilling. Terra Mining (1998-) [3]: trenching.
Drilling	Outokumpu [3]: total 4000 m.
Elements analysed	Au (Fire Assay), 32 element ICP [3], C (Leco?) [3].
Secondary dispersion	Au anomaly in till [3].
Exploration geologist(s) in charge	
	Outokumpu: Erkki Ilvonen; Terra Mining: Tapio Lehto.
ORE	
Siting of gold	Gold is associated with pyrrhotite and pyrite [3].
Major opaques	Pyrite, pyrrhotite [3].
Minor opaques	Chalcopyrite, gold [3].
Gangue	Quartz, albite, carbonate [3].
GEOLOGY	
Major host rocks	Ultramafic (metakomatiite) [3].
Minor host rocks	Carbonaceous phyllite or intermediate tuffite [3].
Geological setting	The host rocks are part of the metasedimentary rock-dominated Matarakoski Formation of the >2050 Ma Savukoski Group of the Palaeoproterozoic Central Lapland Greenstone Belt [1].
METAMORPHISM	
Metamorphic grade	Greenschist facies [1,3].
STRUCTURAL SETTING	
Structural style	Brittle.
Closest major shear	The Sirkka Line which is 2 km south from the deposit [1].
Controlling structure	An E-W trending shear zone? [3].
ALTERATION	
General alteration	Two major stages of alteration (?), interpreted from [2,3]: 1) Albitisation and part of carbonation may have preceded gold mineralisation, taken place before regional deformation, as a synvolcanic, spilitic stage of alteration. 2) Sericitisation, sulphidation and part of carbonation are probably related to the syn-peak metamorphic gold mineralisation.
Proximal alteration	Komatiite: albite-quartz-carbonate-fuchsite [3].
Distal alteration	Komatiite: albite-carbonate-talc [3].
GENETIC MODEL	Clearly epigenetic, “mesothermal” mineralisation with a distinct structural control [3].

References

1. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
2. Kilpelä, M. 1998. Personal communication 16/9/1998.
3. Lehto, T. 1998. Personal communication 14/10/1998.

Name	***Lälleävuoma***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kittilä
Map sheet	2743 01 **X coordinate** 7520900 **Y coordinate** 2548470
Municipality	Kittilä
Nearest town, access	15 km NE from Kittilä. 6 km from a sealed road, 1 km from a gravel road.
MINING	
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oy.
Status of development	Prospect.
Best sections	5.2 m at 3.7 ppm Au [3].
Extent of mineralisation	At surface, about 30 x 150 m [3].
EXPLORATION	
Exploration history	Atri Oy during the late 1940’s [3]: Bedrock mapping, ground magnetic and electromagnetic survey. Outokumpu [3]: Magnetic and IP ground survey.
Elements analysed	By GFAAS: Ag, Au, Co, Cu, Mo, Ni, Pb, Te, Zn, by fire assay: Au, by ICP: Ag, Al, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Sc, Si, Sr, Th, Ti, V, Y, Zn [1].
Exploration geologist(s) in charge	Atri: Birger Ohlsson, Outokumpu: Risto Anttonen.
ORE	
Ore composition	Diamond-drill core, metakomatiite [1]: 3.85 ppm Au, 0.083 ppm Ag, 5.3 ppm As, 6.3 ppm B, 101 ppm Ba, <0.1 ppm Bi, 57 ppm Co, 109 ppm Cu, 20 ppb Hg, <1 ppm Mo, 960 ppm Ni, <2 ppm Pb, 6 ppm Rb, 38100 ppm S, 5.3 ppm Sb, 20.5 ppm Se, 43 ppm Sr, 0.280 ppm Te, <0.5 ppm Th, <0.1 ppm U, 160 ppm V, 4 ppm W, 74 ppm Zn, 35 ppm Zr; 37.5% SiO_2, 0.62% TiO_2, 5.63% Al_2O_3, 11.0% Fe_2O_3, 20.5% MgO, 6.06% CaO, 1.12% Na_2O, 0.06% K_2O, 0.037% P_2O_5, 13.5% LOI.
Enriched elements	Au, CO_2, Na?, S, Sb, Se, Te, W [1].
GEOLOGY	
Major host rocks	Metakomatiite [1].
Geological setting	The komatiitic host rocks are in sequence of basaltic and komatiitic metavolcanic rocks and fine-grained metasedimentary rocks of the >2050 Ma Savukoski Group of the Palaeoproterozoic Central Lapland Greenstone Belt [2].
STRUCTURAL SETTING	
Closest major shear	The Sirkka Line which is adjacent to the mineralisation [3].
Controlling structure	The NW-trending Sirkka Line [3].
ALTERATION	
General alteration	Carbonation, sericitisation [3].
GENETIC MODEL	Clearly epigenetic, “mesothermal” mineralisation with a distinct structural control.
FIGURES	[2]: Regional geology map.

References

1. Nurmi, P.A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
2. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
3. Keinänen, V. 1998. Personal communication 18/8/1998.

Name	***Lammasvuoma***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kittilä
Map sheet	2734 05 **X coordinate** 7501850 **Y coordinate** 2557230
Municipality	Kittilä
Nearest town, access	20 km E from Kittilä. 1 km from a sealed road.
MINING	
Exploration licence no.	4576/1, 4627/1, 4765/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oy (-1992).
Status of development	Prospect.
Best sections	1.2 m at 25 ppm Au, 1 m at 3.5 ppm Au, 1 m at 2.5 ppm Au, 3 m at 2.2 ppm Au, 3 m at 1.8 ppm Au, 10 m at 1.7 ppm Au [1].
EXPLORATION	
Discovery	By Outokumpu on 1989: regional till geochemical survey; the mineralisation was detected by diamond drilling into a geochemical and geophysical anomaly [1].
Exploration history	Outokumpu Oy (1989-1992) [1]: glacial erratic boulder survey, till geochemical survey, ground IP, magnetic and slingram survey, diamond drilling.
Drilling	Outokumpu (1989-1991) [1]: 17 diamond-drill holes.
Exploration geologist(s) in charge	
	Outokumpu: Raimo Hugg.
ORE	
Major opaques	Pyrite [1].
Minor opaques	Chalcopyrite [1].
GEOLOGY	
Major host rocks	“Albite fels” [1] = metakomatiite?
Geological setting	The mineralisation is in a sequence of ultramafic to mafic metavolcanic rocks and arenitic to argillitic metasedimentary rocks [1] of the >2050 Ma Savukoski Group of the Palaeoproterozoic Central Lapland Greenstone Belt [2].
Intrusives	Metamorphosed dolerites to the south, adjacent to the area [1].
METAMORPHISM	
Metamorphic grade	Greenschist facies [1].
STRUCTURAL SETTING	
Structural style	Brittle-ductile or brittle [1].
Closest major shear	A WSW-trending major thrust about 500 m south of the mineralisation; this thrust converges with the Sirkka Line about 7 km east from the mineralisation [2].
Veins	Quartz-carbonate veins [1].
ALTERATION	
General alteration	The “albite fels” apparently looks like an albitised quartzite, although it probably is a metakomatiite [1]. Two major stages of alteration (?), interpreted from [1]: 1) Albitisation and part of carbonation may have preceded gold mineralisation, taken place before regional deformation, as a synvolcanic, spilitic stage of alteration. 2) Sericitisation(?), sulphidation and part of carbonation are probably related to the syn-peak metamorphic gold mineralisation.
GENETIC MODEL	Clearly epigenetic, “mesothermal” mineralisation with a distinct structural control [1].
FIGURES	[1]: Local bedrock map (in colour), drilling section. [2]: Regional geology map.

References

1. Hugg, R. 1987. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Kittilä, Lammasvuoma 1, Lammasvuoma 2 ja Lammasvuoma 3, kaiv. rek. n:o 4576/1, 4627/1 ja 4765/1. Outokumpu Oy, unpublished report. 2 p. (in Finnish)
2. Lehtonen, M .I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.

Name	***Loukinen***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kittilä
Map sheet	2743 01 **X coordinate** 7525500 **Y coordinate** 2541000
Municipality	Kittilä
Nearest town, access	17 km NNE from Kittilä. 12 km from a sealed road, a gravel road to the area.
MINING	
Present holder	Geological Survey of Finland (GTK) 1994-.
Previous holders	Atri Oy (1940s-1950s).
Status of development	Prospect.
Best sections	1.5 m at 5.2 ppm Au, 1 m at 8.5 ppm Au, 12 m at 0.5 ppm Au and 1.25% Cu [2].
Extent of mineralisation	The E-W trending mineralised zone is, at least, 5 km long; it may be continuous, along the Sirkka Line, to the west until the Sirkka mineralisation and to the SSE until the Lälleävuoma mineralisation [2].
EXPLORATION	
Discovery	GTK 1994 [2]: A gersdorffite-rich, auriferous boulder sample received from an amateur prospector; the mineralisation was detected by drilling through overburden to the surface of bedrock.
Exploration history	Atri Oy (1940s-1950s) [2]: regional exploration: bedrock mapping, ground magnetic and electromagnetic survey, diamond drilling. GTK 1994- [2,3]: bedrock mapping, trenching, percussion and diamond drilling, till geochemical and stratigraphy survey, airborne low-altitude magnetic, elecromagnetic, radiometric and gravity survey, ground magnetic and VLF-R survey.
Drilling	Atri Oy [2]: 42 diamond-drill holes in an area of 2 km by 5 km.
Secondary dispersion	Cu-Ni-Au anomalies in till [2].
Exploration geologist(s) in charge	Atri: Birger Ohlsson, GTK: Veikko Keinänen.
ORE	
Siting of gold	Free gold and gold as inclusions or solid solution in pyrite and gersdorffite; the latter is the main(?) siting for gold [2].
Major opaques	Pyrite [3].
Minor opaques	Chalcopyrite, gersdorffite, pyrrhotite, pentlandite, rutile, gold [3].
Gangue	Quartz, Fe dolomite [2,3].
Enriched elements	As, Au, CO_2, Cu, K, S [2,3].
GEOLOGY	
Major host rocks	Metakomatiite, graphitic phyllite [2].
Geological setting	A sequence of komatiitic and tholeiitic metavolcanic rocks and graphitic phyllites [2]. The host rocks are part of the metasedimentary rock-dominated Matarakoski Formation of the >2050 Ma Savukoski Group of the Palaeoproterozoic Central Lapland Greenstone Belt [1].
METAMORPHISM	
Metamorphic grade	Lower- or mid-greenschist facies: interpreted from the references [2] and [3].
STRUCTURAL SETTING	
Structural style	Brittle [2].
Closest major shear	The Sirkka Line [1].
Controlling structure	The mineralisation is in the Sirkka Line [1,2].
Ore fabric	Massive, brecciated [2].
Veins	Auriferous(?) quartz-Fe dolomite veins [2,3].
ALTERATION	
General alteration	Sericitisation, carbonation and sulphidation [2].
Proximal alteration	Metakomatiite: quartz-Fe dolomite-fuchsite ± pyrite, chlorite, rutile [2,3]. Graphitic phyllite: sericite-quartz-carbonate-sulphides-graphite [2].
Intermediate alteration	Metakomatiite: quartz-Fe dolomite-talc-chlorite [2,3].
Distal alteration	Metakomatiite: Fe dolomite-talc-chlorite [2,3].
TIMING	
GENETIC MODEL	Clearly epigenetic, “mesothermal” mineralisation with a distinct structural control [2,3].
FIGURES	[1]: Regional geology map.

References

1. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
2. Keinänen, V. 1998. Personal communications on 19/8/1998 and 23/12/1998.
3. Riikonen, S. 1997. Kittilän kromimarmorien mineralogia. Unpublished MSc thesis, Department of Geology, University of Oulu. 61 p. (in Finnish)

Name	***Muusanlammit***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kittilä
Map sheet	2741 07 **X coordinate** 7521500 **Y coordinate** 2525000
Municipality	Kittilä
Nearest town, access	17 km NNW from Kittilä. 10 km from a sealed road, 0.5-1 km from a gravel road.
MINING	
Exploration licence no.	3542/1, 3678/1, 3788/1, 4584/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oy.
Status of development	Prospect.
Best sections	1.7 m at 7.9 ppm Au (by Atri Oy) [3].
EXPLORATION	
Discovery	Atri Oy, during the late 1940’s, diamond-drilled into a geophysical anomaly [3,4,6]. On 1984, re-discovered by Outokumpu [2]: diamond drilling into geophysical and till geochemical anomalies + reanalysis of core drilled in 1970’s during base-metal exploration.
Exploration history	Atri Oy (1940's-1950's) [2,3,4,5,6]: regional exploration: bedrock mapping, trenching, ground magnetic and electromagnetic survey. Outokumpu (1972-1976, 1983-1990) [2,3,5,6,7,8]: till geochemical survey, bedrock mapping, ground magnetic and slingram survey, trenching, diamond drilling, mineralogical and geochemical studies. During the 1970's and early 1980's, the area was explored and most of the sample material only analysed for base metals.
Drilling	Atri Oy (1940’s-1950’s): 16 diamond-drill holes [3,5,6]. Outokumpu (1972-1976) [6]: seven diamond-drill holes, total 912 m; 1984 and 1990 [2,5]: 6 diamond-drill holes.
Elements analysed	Au, Cu [2]. Ag, Au, Co, Ni (by Atri Oy) [3]. Base metals and S [6,8].
Geophysical response	Magnetic methods show the location of the ultramafic units, and slingram indicates the Fe sulphide-bearing graphitic phyllites [2].
Secondary dispersion	As, Co, Cu, Ni and U show anomalous values in till, but it remains unknown if these are related to Au [8].
Exploration geologist(s) in charge	Atri: Birger Ohlsson, Outokumpu: Risto Anttonen, Osmo Inkinen.
ORE	
Major opaques	Pyrite [3,5,6].
Minor opaques	Pyrrhotite, graphite, arsenopyrite, rutile, gersdorffite, ilmenite, chalcopyrite, pentlandite, Ag-pentlandite, gold [3,5,6].
Gangue	Quartz, ankerite, Fe dolomite, siderite, sericite, chlorite, tourmaline [5].
Enriched elements	As, Au, B, CO2,Cu, S [2,3].
GEOLOGY	
Major host rocks	Graphitic phyllite and tuffite [2,4,5,6].
Minor host rocks	Metakomatiite [4].
Geological setting	The host rocks are part of the metasedimentary rock-dominated Matarakoski Formation of the >2050 Ma Savukoski Group of the Palaeoproterozoic Central Lapland Greenstone Belt [1].
Intrusives	Dolerites which predate all alteration and mineralisation [5].
METAMORPHISM	
Metamorphic grade	Greenschist facies [1,2].
STRUCTURAL SETTING	
Closest major shear	The Sirkka Line, which is here E-W trending, is apparently 0-500 m south from the deposit [1,2].
Controlling structure	Crossing of the Sirkka Line and a N-S trending smaller shear zone [1,4]
ALTERATION	
General alteration	[5,6]: Two apparent, major stages of alteration: 1. Albitisation and part of carbonation may have preceded gold mineralisation, taken place before regional deformation, as a synvolcanic, spilitic stage of alteration. 2. Sericitisation, sulphidation and part of carbonation, with formation of abundant quartz veins, are probably related to the syn-peak metamorphic gold mineralisation.
GENETIC MODEL	Interpreted from the references [2,5,6]: Pre-gold, syngetic(?) chalcopyrite-pyrrhotite mineralisation hosted by the graphitic phyllites; this is overprinted by epigenetic, “mesothermal” gold mineralisation.
FIGURES	[1]: Regional geology map.

References

1. Lehtonen, M. ., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.

2. Inkinen, O. 1991. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Kittilä, Muusanlammit, Muusanlammit II, Muusanlammit III ja Muusanlammit IV, kaiv. rek. n:o 3542/1, 3678/1, 3788/1 ja 4584/1. Outokumpu Oy, unpublished report 080/3712/OI/91. 2 p. (in Finnish)
3. Vesanto, J. 1978. Sirkan malmi ja sitä ympäröivä kallioperä. Unpublished MSc thesis, Department of Geology, University of Oulu. 89 p. (in Finnish)
4. Keinänen, V. 1998. Personal communication on 19/8/1998.
5. Roos, S. 1987. Lapista valitut vertailukohteet: Muusanlammit. In: H. Papunen (ed.) Lapin vulkaniittien tutkimusprojekti. Loppuraportti. Department of Geology, University of Turku, unpublished report. 70-74. (In Finnish)
6. Reino, J. 1976. Kittilä, Muusanlammit. Outokumpu Oy, unpublished report 001/2741/JR/76. 6 p. (in Finnish)
7. Wennervirta, H. 1972. Moreenin pintatutkimus, Muusanlammet, Kittilä. Outokumpu Oy, unpublished report 062/2741 07/HW/72. 2 p. (in Finnish)
8. Kokkola, M. 1975. Moreeni- ja kalliomursketutkimus, Kittilä, Muusanlammit. Outokumpu Oy, unpublished report 062/2741/MK/75. 3 p. (in Finnish)

Name	***Pahkavaara***				
GENETIC TYPE	Orogenic ‘mesothermal’.				
LOCATION					
Geological domain	Lapland	**Belt**	Sodankylä		
Map sheet	3643 07	**X coordinate**	7403000	**Y coordinate**	3562000
Municipality	Salla				
Nearest town, access	43 km E from Kemijärvi. 15 km from a sealed road, 1 km from a gravel road.				
MINING					
Present holder	Geological Survey of Finland (GTK).				
Status of development	Prospect.				
Best sections	1 m at 1.66 ppm Au [1].				
EXPLORATION					
Discovery	By GTK on 1997(?) [1].				
Exploration history	GTK [1]: bedrock mapping, till geochemical survey, diamond drilling.				
Elements analysed	By ICP: Ag, As, B, Ba, Be, Cd, Co, Cr, Cu, Fe, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Sc, Sr, Th, Ti, V, Y, Zn and by GAAS: Au, Pd, Te [1].				
Exploration geologist(s) in charge					
	GTK: Heikki Pankka.				
ORE					
Major opaques	Pyrrhotite, pyrite [1].				
Minor opaques	Chalcopyrite [1].				
Ore composition	1 m section, ICP and GFAAS, Aqua regia digestion(?): 1660 ppb Au, <1 ppm Ag, < 5 ppm As, 4 ppm B, 38.7 ppm Ba, <0.1 ppm Be, 26 ppm Co, 101 ppm Cu, 2.87% Fe, 0.99% K, 1.7 ppm La, 23.7 ppm Li, 0.87% Mg, 120 ppm Mn, 1.1 ppm Mo, 16.2 ppm Ni, 7 ppm Pb, <1 ppb Pd, 5570 ppm S, <10 ppm Sb, 143 ppb Te, 6 ppm Th, 12.3 ppm Zn [1].				
GEOLOGY					
Major host rocks	Arkosic gneiss or greywacke gneiss [1].				
Geological setting	The mineralisation is in a sequence of psammitic and pelitic gneisses, possibly in a metaturbidite sequence [1].				
METAMORPHISM					
Metamorphic grade	Mid- or upper-mphibolite facies [1].				
STRUCTURAL SETTING					
Structural style	Ductile [1].				
Veins	Up to 5 cm wide quartz veins [1].				
ALTERATION					
General alteration	Biotitisation, formation of diopside(?) [1].				
GENETIC MODEL	Clearly epigenetic, “mesothermal” mineralisation with a distinct structural control [1].				

References

1. Pankka, H. 1998. Personal communication 15/9/1998.

Name	***Pahtavaara***				
GENETIC TYPE	Orogenic ‘mesothermal’.				
LOCATION					
Geological domain	Lapland	**Belt**	Sodankylä		
Map sheet	3714 05	**X coordinate**	7504900	**Y coordinate**	3475300
Municipality	Sodankylä				
Nearest town, access	25 km NW from Sodankylä. 5 km from a sealed road, a gravel road to the mine.				
MINING					
Mining concession no.	3921/1a.				
Present holder	Terra Mining (William Resources Inc.) 1991-.				
Previous holders	Geological Survey of Finland (GTK) (-1991).				
Status of development	Open pit				
When mined	1996-				
Resources	0.1843 Mt at 6.7 ppm Au [12]; >3 Mt [13].				
Total production	1996-97: 1265 kg Au [13].				
Total in-situ gold	10500 kg Au [13].				
Best sections	6.5 m at 32.6 ppm Au [8]. 10 m at 11.7 ppm Au, 6 m at 10.7 ppm Au, 7 m at 6.6 ppm Au [10].				
Extent of mineralisation	The set of lodes extend >400 m along a NW trend and dip to the north at about 70-80° [18].				
Lodes	The lodes are 5-10 m wide [5], have an E-W strike [18].				
EXPLORATION					
Discovery	By the GTK on 1985: high gold grade and visible gold in outcrop. The discovery was preceded by detection of Au anomalies in till and the discovery of the extensive “skarn” zone in the bedrock during regional exploration [1,3,8].				
Exploration history	GTK 1984-1991 [1,3,4,5,7,8,17]: Regional and detailed till geochemistry and stratigraphy, systematic sampling from bedrock surface below the overburden by percussion drilling, detailed outcrop mapping, trenching, diamond drilling, detailed thin section studies, microprobe analyses on silicates and gold, C and O isotopes on carbonates; low-altitude airborne gravimetric, magnetic, electromagnetic and radiometric survey; systematic ground magnetic and slingram survey, also ground gravity, ATM, IP and VLF-R surveys were tested in the area, biogeochemical survey of gold. Terra Mining 1991- [5,9,10]: Diamond and RC drilling.				
Drilling	GTK (1986-87): 114 diamond-drill holes, total 3639 m [1]. Terra Mining (1991-): A large number of diamond-drill and RC holes [5], total drilling by 16/9/1998 more than 45 km [18].				
Elements analysed	Major components by XRF; CO2, H2O, S by Leco; Ba, Co, Cr, La, Ni, Rb, Sb, Sc, Sm by NAA; Ag and Cu by ICP; Au by GFAAS [1]. Major components by XRF and ICP; CO_2, H_2O, S by Leco; Au, Ce, Cr, Eu, La, Lu, Nd, Sc, Sm, Tb, Yb by INAA; Cu, V, Zn by DCP; Ba, Cr and Sr also by XRF; Co, Sc, V, Zn also by ICP; Au and Te by GFAAS [3]. Au, Co, Cu, Mn, Ni, Pb and Zn by AAS and Fire Assay [8].				
Economic evaluations	Preliminary feasibility study by GTK on 1990 [12]. Feasibility study by Terra Mining (1991-1996) [5,10].				
Geophysical response	No response or a weak negative anomaly by electromagnetic methods for the mineralisation [8]. Good response for unaltered metakomatiite and weak response for altered metakomatiite in magnetic survey [8].				
Primary dispersion	Ba- and Mn-anomalies apparently cover most of the altered rocks [1,7]. Moderate positive correlation between Au and Ba in samples with >20 ppb Au [3]. Along strike to the WNW-NW, local(?) enrichment of gold in bedrock up to 6 km from the deposit [8].				
Secondary dispersion	A combined Au-Cu-Co-Ni anomaly in till: arcuate, E-W trending, 15 km long [1,8]. This includes an inner anomaly formed by the combination Au-Ba-Sr-Mn, which envelopes the Au deposit and the most altered rocks [1]. In vegetation, Au is enriched in juniper and crowberry, and defines an anomaly around the deposit [8].				
Exploration geologist(s) in charge					
	GTK: Eelis Pulkkinen, Esko Korkiakoski; Terra Mining: Markku Kilpelä.				
ORE					
Siting of gold	Nearly all is free native gold, chiefly between silicate, carbonate and baryte grains, but locally also as inclusions in magnetite. Minor gold as inclusions in pyrite and chalcopyrite [1,3,8,16]. Visible gold especially occurs in coarse-grained amphibole rock with quartz-baryte veins [3].				
Fineness	99.7% Au [1]. 99.02% Au, 0.07% Ag, 0.25% Bi [3].				
Major opaques	Magnetite, pyrite [1,3,4,5,8,16].				
Minor opaques	Chalcopyrite, rutile, pentlandite, pyrrhotite, violarite, millerite, cubanite, gold, clausthalite, merenskyite [1,3,4,8,16].				
Gangue	Quartz, baryte, tremolite, scheelite [1,2,3,4,8].				

Ore composition	23.00 ppm Au, 0.2 ppm Ag, 1000 ppm Ba, 41 ppm Co, 427 ppm Cr, 3 ppm Cu, 0.43 ppm La, 605 ppm Ni, 60 ppm Rb, 0.2 ppm Sb, 14 ppm Sc, 0.66 ppm Sm; 54.81% SiO_2, 0.10% TiO_2, 1.64% Al_2O_3, 11.70% Fe_2O_3, 17.10% MgO, 10.95% CaO, <0.00% Na_2O, 0.48% K_2O, <0.00% P_2O_5, 2.16% H_2O, 0.30% CO_2 [1].
	1.00-33.00 ppm Au, 45-80 ppm Co, 18-31 ppm Sc, 20-260 ppm Sr, 0.01-0.08 ppm Te, 180-215 ppm V, 6-150 ppm W, 15-40 ppm Zn, 44-54% SiO_2, 0.10-0.76% TiO_2, 1.88-6.84% Al_2O_3, 12.9-24.9% Fe_2O_3, 16.5-26.0% MgO, 1.8-10.0% CaO, <0.00-0.95% Na_2O, <0.00-2.97% K_2O, <0.00-0.07% P2O5, 0.25-6.64% CO_2, 0.01-0.81% S [3].
Enriched elements	Au, Ag, B, Ba, CO_2, Fe(?), K, Mn, Na (locally),S, Sr [1]. Au, Ba, Ca, CO_2, K, Na, P, Si, Sr, Te and W in the proximal and intermediate areas; in addition, LREE in the most carbonate-rich parts [3,5].
Ore fluid	Biotitisation stage: CO_2-H_2O fluid, slightly reducing, Au-, K- and S-bearing; S content was relatively low, however [3]. Amphibole-overgrowth stage: CO_2-undersaturated, silica-saturated, Ba-rich?, slightly oxidising [3].
Stable isotope data	$\delta^{18}O$ (SMOW): +10.82 – +11.47‰ and $\delta^{13}C$ (PDB): -3.17 – -0.40‰ (carbonates throughout the alteration halo) [3].
Pb isotope data	Mantle-derived lead [14]. Pb-Pb age for whole rock 1814±32 Ma, and for pyrite and magnetite 1811±87 Ma [14].
GEOLOGY	
Major host rocks	Al-depleted(?) metakomatiites [3].
Geological setting	The deposit is in an E-W trending, 40 km long, 5 km wide and several kilometres thick sequence of komatiitic lavas and pyroclastic rocks and komatiite-related mafic metavolcanic rocks, the Sattasvaara Formation, in the Palaeoproterozoic Central Lapland Greenstone Belt [1,3,5,11,17]. The deposit is near the northern margin of the sequence, in the contact zone between a komatiitic pyroclastic and a komatiitic lava unit [1,3].
METAMORPHISM	
Metamorphic history	Progressive regional metamorphism peaked during the crystallisation of tremolite and recrystallisation of minerals produced by the early alterations, like carbonate(s) and talc [1].
Metamorphic grade	Upper-greenschist facies, based on mineral assemblages given in the references [1,3].
Metamorphic mineral assemblage	Pyroclastic rock: serpentine-chlorite-tremolite-antophyllite [1]; tremolite-talc-chlorite-dolomite(?)-antophyllite [2,3,11].
	Lava: tremolite-antophyllite(?) ± chlorite, carbonate, plagioclase [1,3,11].
STRUCTURAL SETTING	
Structural style	Brittle-ductile [1,3].
Controlling structure	Crossing of SE-NW and NE-SW trending fault or shear zones [1,3]. SW-NE trending fault which dips to the north by 80° [8].
Deformation history	At least two stages of folding, the older is characterised by E-W trending and the younger by NE-trending schistosity [1].
Ore fabric	Massive, nemato-lepidoblastic to granoblastic [1,3].
Veins	Distal and intermediate talc-carbonate ± pyrite and proximal quartz-baryte ± carsbonate, tourmaline, gold veins [1,3]. A continuum exists between these two vein types which both may contain variable volumes of actinolite [3].
ALTERATION	
General alteration	Early carbonation, chloritisation, intense biotitisation ± tourmalinisation, and pyritisation predate peak metamorphism while the following alterations post-date peak metamorphism: the late formation of talc, chloritisation, albitisation, formation of richterite, minor biotitisation and minor tourmalinisation [1].Syn-peak deformation biotitisation and post-peak tremolite overgrowth [3]. The extent of the alteration envelope (intermediate + proximal alteration?) is 100 x 600 m [3].The extent of the alteration envelope is 100 x 500 m [5].The extent of the alteration halo is 30-120 m x 600 m [8].
	[15]: Three possible stages of alteration: 1) Albitisation and part of carbonation may have preceded gold mineralisation. 2) Biotitisation, formation of nematoblastic tremolite and additional carbonation, with formation of abundant quartz veins, are most probably related to the syn-peak metamorphic gold mineralisation. 3) Formation of overprinting tremolite porphyroblasts took place after gold mineralisation - this is, in fact, not an alteration stage.
Proximal alteration	Unfoliated, biotite-talc-dolomite/ankerite-tremolite/actinolite-quartz-pyrite-rutile ± albite, richterite, barite, magnetite, tourmaline; also coarse-grained, nearly mono-mineralic amphibole rock with locally abundant quartz and barite and minor amounts of dolomite or ankerite, talc and albite [1,2,3,15].
Intermediate alteration	Talc-carbonate-chlorite-biotite-rutile-tremolite-quartz ± albite, magnetite, tourmaline [1,2,3,15].
Distal alteration	Discontinuous, about 8 km long, 100-300(?) m wide, generally E-W trending “skarn” [1] zone charcterised by the mineral assemblage chlorite-calcite-talc-tremolite ± albite [1,2]. At Pahtavaara, the domain of continuous alteration and formation of penetrative foliation is WSW-trending, >500 m long (open to the WSW) and 100-200 m wide [1,2,15].
TIMING	Pb-Pb age for whole rock 1814±32 Ma, and for pyrite and magnetite 1811±87 Ma; if these represent the second stage of mineralisation, the age of ca. 1820 Ma can be considered as the minimum age for the main stage of gold mineralisation [14].
GENETIC MODEL	[3]: Biotitisation-dominated, reducing alteration in a komatiitic sequence was the main mineralisingstage during peak- to slightly post-peak deformation. This was followed by amphibole overgrowth withpartial decarbonation of rocks altered during the first stage under oxidising conditions; this was another mineralising stage, possibly just remobilising gold. The coarse, visible gold was formed during the latter stage.
	[14]: Mineralisation took place at ca. 1840-1870 Ma indicating the formation of late-orogenic metamorphic fluid with lead form mantle that was responsible for the gold mineralisation.

[15]: Albitisation and part of carbonation may have preceded gold mineralisation, "preparing ground", i.e. making the komatiitic host rock locally more competent than the surrounding talc-chlorite schist and, hence, a structurally favourable site for the mineralising fluids to precipitate gold. Biotitisation, formation of nematoblastic tremolite and additional carbonation, with formation of abundant quartz veins, are most probably related to the syn-peak metamorphic gold mineralisation. Formation of overprinting tremolite porphyroblasts took place after gold mineralisation.

[1] (a no more favoured model): Early, synvolcanic, submarine alteration with a significant metamorphic fluid component: carbonation, biotitisation, chloritisation, sulphidation, tourmalinisation and Au-mineralisation (most of gold). This was followed by syn-metamorphic formation of tremolite porphyroblasts and retrograde(?) formation of talc, quartz-baryte veins, minor chloritisation and tourmalinisation, oxidation of Fe sulphides, replacement of other Ti-bearing minerals by rutile, and mobilisation and re-precipitation of gold into the association of the quartz-baryte veins.

Post-mineralisation modifications

Tremolite overgrowth ? [3].

FIGURES

[1]: Outcrop and thin section photographs.
[3]: Jensen and REE plots, local geology maps, thin section photographs.
[8]: Local geology map, drilling plan.
[11]: Regional geology map.

References

1. Hulkki, H. 1990. Sodankylän Sattasvaaran komatiittikompleksin Au-kriittinen muuttumisvyöhyke. Unpublished MSc thesis. Department of Geology, University of Helsinki. 190 p. (in Finnish)
2. Niiranen, K. 1998. Personal communication 22/2/98.
3. Korkiakoski, E. 1992. Geology and geochemistry of the metakomatiite-hosted Pahtavaara gold deposit in Sodankylä, northern Finland, with emphasis on hydrothermal alteration. Geological Survey of Finland, Bulletin 360. 96 p.
4. Korkiakoski, E., Karvinen, A. & Pulkkinen, E. 1989. Geochemistry and hydrothermal alteration of the Pahtavaara gold mineralization, Finnish Lapland. Geological Survey of Finland, Special Paper 10, 83-89.
5. Korkiakoski, E. & Kilpelä, M. 1997. The komatiite-hosted Pahtavaara gold mine near Sodankylä, northern Finland. In: E. Korkiakoski & P. Sorjonen-Ward (eds) Ore deposits of Lapland in northern Finland and Sweden. Geological Survey of Finland, Guide 43, 27-29.
6. Korkiakoski, E. & Räsänen, J. 1993. Komatiites and gold: the two-stage alteration of the Pahtavaara gold deposit, northern Finland. In: IAGOD International Symposium on Mineralization Related to Mafic and Ultramafic Rocks with a special session on Alkaline and carbonatitic magmatism and associated mineralization, Orleans, France, 1-3 September, 1993. Terra Abstracts. Abstract supplement no. 3 to Terra Nova 5, p. 24.
7. Pulkkinen, E., Ollila, J., Manner, R. & Koljonen, T. 1986. Geochemical exploration for gold in the Sattasvaara komatiite complex, Finnish Lapland. In: Prospecting in areas of glaciated terrain 1986: papers presented at the Seventh International Symposium organised by The Institution of Mining and Metallurgy and The Geological Survey of Finland, Kuopio, 1-2 September, 1986. London: The Institution of Mining and Metallurgy, 129-137.
8. Karvinen, A. 1990. Pahtavaaran kultatutkimukset Sodankylässä vuosina 1987-1989. Geological Survey of Finland, unpublished report M19/3714/-90/1/10. 19 p. (in Finnish)
9. William Resources Inc. 1997. Press release 16/4/1997.
10. William Resources Inc. 1997. Press release 2/7/1997.
11. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
12. Parkkinen, J. 1990. Sodankylän Pahtavaaran kulta-aiheen arviointi. Geological Survey of Finland, unpublished report M19/3714/-90/2/10. 13 p. (in Finnish)
13. Alaniska, H. 1998. Personal communication (March 1998).
14. Mänttäri, I. 1995. Lead isotope characteristics of epigenetic gold mineralization in the Palaeoproterozoic Lapland greenstone belt, northern Finland. Geological Survey of Finland, Bulletin 381. 70 p.
15. Eilu, P. 1997. Orogenic lode-gold deposits: Notes to accompany samples from deposits located on the Fennoscandian Shield. University of Turku, Department of Geology and Mineralogy, Publication 35, 1st edition. 14 p.
16. Kojonen, K. & Johansson, B. 1988. Pahtavaaran Au-malmiaiheen malmimineraaleista. Geological Survey of Finland, unpublished report M40/3714/-88/1/41.2. 2 p. (in Finnish)
17. Lanne, E. 1995. Sattasvaaran komatiittimuodostuman geofysikaalinen rakennetutkimus. Geological Survey of Finland, unpublished report Q19/3714/95/1/22.86. 27 p. (in Finnish)
18. Kilpelä, M. 1998. Personal communication. 16/9/1998.

Name	***Palokiimanselkä***				
GENETIC TYPE	Orogenic ‘mesothermal’?				
LOCATION					
Geological domain	Lapland	**Belt**	Sodankylä		
Map sheet	3742 04	**X coordinate**	7558000	**Y coordinate**	3510000
Municipality	Sodankylä				
Nearest town, access	65 km N from Sodankylä. Highway 4 is 6.5 km from the area, a gravel road from the highway to the area.				
MINING					
Present holder	OPEN FOR ACQUISITION.				
Previous holders	Geological Survey of Finland (GTK).				
Status of development	Prospect.				
EXPLORATION					
Exploration history	GTK [1]: Bedrock mapping, fluid inclusion study.				
ORE					
Major opaques	Haematite, magnetite [1]				
Gangue	Quartz, albite [1].				
Ore fluid	24% NaCl eq., oxidising, formed at 2.0 kbar if T was 280°C (the minimum temperature) [1].				
GEOLOGY					
Major host rocks	Hornblende gneiss, ab-ep-qz- and qz-ser-rock [1].				
Geological setting	Metasedimentary Virttiövaara Formation [2] host the mineralised veins.				
Intrusives	The 1.7 Ga, post-orogenic, Nattanen Granites a few hundreds of metres from the deposit [1].				
STRUCTURAL SETTING					
Veins	Quartz-haematite-albite-magnetite veins [1].				
ALTERATION					
General alteration	Formation of albite-epidote-quartz- and quartz-sericite-rocks ?				
GENETIC MODEL	Orogenic “mesothermal” deposit. Au possibly transported as chloride complex [1].				
Post-mineralisation modifications					
	Replacement of haematite by magnetite by the thermal effect of the Nattanen granite? However, this is not supported by the types of fluid inclusions present in quartz [1].				
FIGURES	[2]: Regional geology map.				

References

1. Kinnunen, K.A. 1980. Fluidisulkeuma-tutkimus Sodankylän Palokiimaselän kultaesiintymän kvartsijuonista. Geological Survey of Finland, unpublished report M19/3742/-80/1/10. 9 p (in Finnish).
2. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.

Name	***Palovaara (Jerusaleminjänkä)***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kittilä
Map sheet	2734 06 **X coordinate** 7512200 **Y coordinate** 2554250
Municipality	Kittilä
Nearest town, access	17 km NE from Kittilä. 10 km from a sealed road, 500 m from a gravel road.
MINING	
Exploration licence no.	4844/1, 5030/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK) (1987-1991).
	Outokumpu Oy (1991-1994).
Status of development	Prospect.
Best sections	2 m at 4.8 ppm Au [2].
Lodes	Several parallel lodes [2,3].
EXPLORATION	
Discovery	GTK 1987 [4]: drilling into a structurally significant area during regional bedrock mapping.
Exploration history	GTK 1987-1991 [3,4]: High- and low-altitude airborne magnetic, electromagnetic, gravimetric and radiometric survey, regional till stratigraphy and geochemistry survey, diamond-drilling, and a detailed lithogeochemical and petrographical study.
	Outokumpu Oy 1991-1993 [2]: Till geochemical survey, trenching, bedrock mapping, ground geophysical survey, diamond drilling.
Drilling	Outokumpu [2]: 20 diamond-drill holes.
	GTK [3]: three diamond-drill holes
Elements analysed	Major elements by XRF; As, Au, Ba, Br, Ce, Co, Cr, Cs, Cu, Eu, La, Lu, Nd, Ni, Rb, S, Sb, Sc, Sm, Ta, Tb, Th, U, V, Yb and Zr by INAA, detection limit for Au 1 ppm (!) [3].
Secondary dispersion	Au anomaly in till.
Exploration geologist(s) in charge	
	Outokumpu: Risto Anttonen, Erkki Ilvonen.
ORE	
Major opaques	Pyrite [3].
Gangue	Quartz, tourmaline [3,4].
Enriched elements	Sodium enrichment and K depletion during diagenesis and synvolcanic spilitisation [3]. Enrichment of Mn, K, Au, As, CO_2, Cs, Rb and Ba ± Cu and U during gold mineralisation - interpreted from [3].
GEOLOGY	
Major host rocks	“Albitite” [2]; metasedimentary rocks [3].
Minor host rocks	Metakomatiites and mafic metalavas [2,3].
Geological setting	An overturned sequence of conformable dolerites, Fe-tholeiitic mafic and komatiitic ultramafic metavolcanic rocks, and metasedimentary rocks of the Matarakoski Formation of the >2050 Ma Savukoski Group of the Palaeoproterozoic Central Lapland Greenstone Belt [1,2,3].
Intrusives	Pre-gold mineralisation, Fe-tholeiitic, dolerites and pre-gold(?), calc-alkaline lamprophyres [3].
METAMORPHISM	
Metamorphic grade	Mid-greenschist facies [3].
Metamorphic mineral assemblage	Ultramafic rocks: talc-serpentine-chlorite-magnetite and tremolite-chlorite-magnetite [3]. Mafic rocks: albite-chlorite-magnetite [3]. Lamprophyres: biotite-albite-chlorite-apatite ± talc [3]. Quartzites and conglomerates: quartz-albite ± sericite [3]. Metasiltstones: quartz-albite-biotite ± sericite [3]. Metatuffites: quartz-albite-chlorite ± biotite, magnetite [3].
STRUCTURAL SETTING	
Structural style	Brittle(-ductile) [3].
Closest major shear	The Sirkka Line is 1-1.5 km to the NE from the area.
Controlling structure	A set of parallel(?), minor shear zones [3].
Ore fabric	Granoblastic and brecciated, nematoblastic where the sericite content is high [3].
Veins	Quartz-tourmaline-pyrite veins [3,4].
ALTERATION	
General alteration	The following is based on the reference 3: The metasedimentary rocks were intensely albitised under diagenesis. During synmagmatic stage(s), all rocks (except the lamprophyres) were variably spilitised; this is chiefly reflected by chloritisation, in ultramafic rocks, also by formation of talc and in all rocks by partial carbonation. During deformation, the rocks were again carbonated and, at least locally, sericitised.

Proximal alteration Ultramafic rocks: fuchsite-ankerite-quartz-rutile ± pyrite [3].

Mafic rocks: albite-sericite-ankerite-rutile ± biotite, pyrite [3].

Metasedimentary rocks: quartz-sericite-ankerite-rutile ± pyrite, albite [3].

Lamprophyres: biotite-sericite-quartz-carbonate-rutile-apatite [3].

GENETIC MODEL Clearly epigenetic, "mesothermal" mineralisation with a distinct structural control [3,4]. Amphibole geobarometry: synvolcanic alteration at <0.5 kbar, syndeformational alteration between 1-2 kbar [3]. Chlorite geothermometry: 300-330 ± 30°C [3].

Post-mineralisation modifications

Post-deformation growth of tremolite and chlorite in ultramafic rocks [3].

FIGURES [1]: Regional geology map.
[2]: Local geology + drill hole locations, section Y 554.240: drill holes 8 and 17 with assay data.
[3]: Figs 30-33: cross section and alteration maps, geochemical plots.

References

1. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
2. Anttonen, R. 1994. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Kittilä, Jerusaleminjänkä, kaiv. rek. n:o 4844/1, ja Jerusaleminjänkä 2, kaiv. rek. n:o 5030/1. Outokumpu Oy, unpublished report 080/2734 05/RSA/94. (in Finnish)
3. Eilu, P. 1994 Hydrothermal alteration in volcano-sedimentary rocks in the Central Lapland greenstone belt, Finland. Geological Survey of Finland, Bulletin 374. 145 p.

Name	***Pikku-Mustavaara***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kittilä
Map sheet	2734 08 **X coordinate** 7503600 **Y coordinate** 2561500
Municipality	Kittilä
Nearest town, access	25 km E from Kittilä. A sealed road adjacent to the area.
MINING	
Exploration licence no.	4296/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	European Mining Finances - Onas Resources J.V., Geological Survey of Finland (GTK) (1987-1989?).
Status of development	Prospect.
Best sections	1 m at 11.8 ppm Au, 2.5 m at 10 ppm Au, 5 m at 2.8 ppm Au and 0.3% Cu [3,5].
Extent of mineralisation	At surface, at least 100x300 m [3].
Lodes	A set of small(?), scattered lodes of irregular shape [3].
EXPLORATION	
Discovery	GTK, early 1980’s [3,5]: An outcrop sample with 0.5 ppm Au discovered during regional lithogeochemical survey.
Exploration history	GTK [1,3,4] 1987-89: High- and low-altitude airborne magnetic, electromagnetic, gravimetric and radiometric survey, ground magnetic and IP survey, regional and local (for an area of 200 x 300 m) till stratigraphy and geochemistry, bedrock mapping, trenching, systematic percussion drilling to the surface of bedrock, diamond drilling, petrographic studies. Onas Resources: trenching.
Drilling	GTK [3]: Four diamond-drill holes, total 381 m.
Elements analysed	Au, As, Cu, S [3].
Exploration geologist(s) in charge	GTK: Veikko Keinänen.
ORE	
Siting of gold	Related to sulphides [4].
Major opaques	Pyrite, arsenopyrite, chalcopyrite [1,4].
Minor opaques	Chalcopyrite, pyrrhotite, gersdorffite, pentlandite, galena, gold, native tellurium [3,4].
Gangue	Quartz, Fe dolomite, baryte [4].
Enriched elements	As, Au, Ba, CO2, Cu, K, S, Te [1,4].
GEOLOGY	
Major host rocks	Albitised, graphitic phyllite [1,3,5].
Minor host rocks	Metakomatiite, chert [1,3,5].
Geological setting	The mineralisation is in the contact zone between ultramafic metavolcanic rocks and graphitic schists, in the metasedimentary rock dominated Matarakoski Formation of the >2050 Ma Savukoski Group of the Palaeoproterozoic Central Lapland Greenstone Belt [2,5].
STRUCTURAL SETTING	
Structural style	Brittle [1].
Closest major shear	A WSW-trending major thrust adjacent to the mineralisation; this thrust converges with the Sirkka Line about 1-2 km east from the mineralisation [2].
Controlling structure	Convergence of the WSW-trending thrust and the Sirkka Line (?) [2].
Veins	Carbonate and quartz-carbonate veins [3,5].
ALTERATION	
General alteration	Intense albite-carbonate alteration in the contact zone between the main rock units [3].
Proximal alteration	Metakomatiite: quartz-Fe dolomite-magnesite-fuchsite ± albite, chlorite, rutile [4].
GENETIC MODEL	Clearly epigenetic, “mesothermal” mineralisation with a distinct structural control [1,3,4].
FIGURES	[1]: Local bedrock map. [2]: Regional geology map.

References

1. Härkönen, I. & Keinänen, V. 1989. Exploration of structurally controlled gold deposits in the Central Lapland greenstone belt. Current Research 1988, Geological Survey of Finland, Special Paper 10, 79-82.
2. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.

3. Keinänen, V. 1990. Tutkimustyöselostus Kittilän kunnassa valtausalueella Pikku-Mustavaara (Kaivosrekisterinumero 4296/1) suoritetuista kupari- ja kultatutkimuksista vuosina 1987-89. Geological Survey of Finland, unpublished report M06/2734/-90/1/10. 2 p. (in Finnish)
4. Riikonen, S. 1997. Kittilän kromimarmorien mineralogia. Unpublished MSc thesis, Department of Geology, University of Oulu. 61 p. (in Finnish)
5. Keinänen, V. 1998. Personal communication 20/8/1998.
4. Keinänen, V. 1998. Personal communication 15/08/1998.

Name	***Rovaselkä***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kittilä
Map sheet	2744 05 **X coordinate** 7565240 **Y coordinate** 2553320
Municipality	Kittilä
Nearest town, access	60 km NE from Kittilä. 45 km from a sealed road, 8 km from a gravel road.
MINING	
Exploration licence no.	3793/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oy (1984-1987).
Status of development	Prospect.
Best sections	1.2 m at 2.1 ppm Au [1].
EXPLORATION	
Discovery	Outokumpu 1984 [3]: detected by ground geophysical survey and diamond drilling on a target area selected after regional mapping and till geochemical survey.
Exploration history	Outokumpu 1984-1987 [3]: bedrock mapping, ground magnetic and electromagnetic survey, till geochemical survey, diamond drilling.
Drilling	Outokumpu [3]: 5 diamond-drill holes, total 368 m.
Elements analysed	By GFAAS: Ag, Au, Co, Cu, Mo, Ni, Pb, Te, Zn, by fire assay: Au, by ICP: Ag, Al, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Sc, Si, Sr, Th, Ti, V, Y, Zn [1].
Geophysical response	Strong response on slingram by Fe sulphide-rich rocks in the area [3].
Exploration geologist(s) in charge	Outokumpu: Risto Anttonen, Rauno Hugg.
ORE	
Ore composition	Diamond-drill core [1]: 0.350 ppm Au, 0.323 ppm Ag, 1100 ppm As, 41.9 ppm B, 374 ppm Ba, 1.6 ppm Bi, 56 ppm Co, 544 ppm Cu, <5 ppb Hg, 19 ppm Mo, 4335 ppm Ni, 21 ppm Pb, 61 ppm Rb, 139000 ppm S, <0.2 ppm Sb, 7.70 ppm Se, 30 ppm Sr, 0.200 ppm Te, 1.9 ppm Th, 4.7 ppm U, 230 ppm V, <0.5 ppm W, 66 ppm Zn, 70 ppm Zr; 41.1% SiO_2, 0.47% TiO_2, 5.27% Al_2O_3, 39.7% Fe_2O_3, 1.70% MgO, 1.42% CaO, 0.22% Na_2O, 1.58% K_2O, 0.13% P_2O_5, 8.47% LOI.
Enriched elements	Au, Ag, As, Bi, Cu, Ni, Pb, S, Se, Te [1].
GEOLOGY	
Major host rocks	“Sulphide-rich schists” [3].
Geological setting	The deposit is in the contact zone between mafic metavolcanic rocks and synorogenic (ca.1.88 Ga), Hetta-type granitoid [2,3]. The metavolcanic(?) rocks are part of a sequence in the chiefly metavolcanic rocks of the Vesmajärvi Formation of the >2000 Ma Kittilä Group of the Palaeoproterozoic Central Lapland Greenstone Belt [2].
Intrusives	The deposit is adjacent to a synorogenic granitoid [3].
STRUCTURAL SETTING	
Controlling structure	A NW-trending shear or fault zone [2].
GENETIC MODEL	Clearly epigenetic, “mesothermal” mineralisation with a distinct structural control.
FIGURES	[2]: Regional geology map. [3]: Local geology and drill plan, drilling profile with holes ROV-2, -3 and -4.

References

1. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
2. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
3. Anttonen, R. 1987. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Kittilä, Rovaselkä, kaiv. rek. n:o 3793/1. Outokumpu Oy, unpublished report 080/2744 05/RSA/87. 1 p. (in Finnish)

Name	***Ruoppapalo***				
GENETIC TYPE	Orogenic 'mesothermal'.				
LOCATION					
Geological domain	Lapland	**Belt**	Kittilä		
Map sheet	3722 07	**X coordinate**	7551600	**Y coordinate**	3439700
Municipality	Kittilä				
Nearest town, access	53 km NE from Kittilä. 35 km from a sealed road, 0.5 km from a gravel road.				
MINING					
Exploration licence no.	6161/1.				
Present holder	Geological Survey of Finland (GTK).				
Status of development	Prospect.				
Best sections	4 m at 2.7 ppm Au, 1 m at 3.2 ppm Au (channel sampling on outcrop) [1].				
Extent of mineralisation	Unknown (1998), open along strike and in depth [1].				
EXPLORATION					
Discovery	GTK 1996 [1]: A regional Au anomaly in till was detected on 1986. This anomaly encloses a set of ground slingram, VLR and magnetic anomalies. The geophysical anomalies and its surroundings were investigated by percussion drilling into bedrock surface and the mineralisation was detected by this drilling.				
Exploration history	GTK 1986- [1]: High- and low-altitude airborne magnetic, electromagnetic and radiometric survey, ground magnetic, slingram, VLF-R, gravimetric and IP survey, regional and local till stratigraphy and geochemistry, bedrock mapping, trenching, percussion drilling into the surface of bedrock.				
Geophysical response	None known [1].				
Exploration geologist(s) in charge	GTK: Ilkka Härkönen.				
ORE					
Siting of gold	Free gold associated with carbonate [1]				
Major opaques	Pyrite [1].				
Minor opaques	Arsenopyrite, gold [1].				
Gangue	Quartz, carbonate [1]				
GEOLOGY					
Major host rocks	Intermediate dykes ("albitites") [1].				
Minor host rocks	Mafic metavolcanic rock (lava?) and granodiorite [1].				
Geological setting	The deposit is in the contact of the Ruoppapalo granitoid and mafic metavolcanic country rocks of the granitoid. The volcanic host rocks probably belong to the Kautoselkä Formation of the >2000 Ma Kittilä Group of the Palaeoproterozoic Central Lapland Greenstone Belt [2].				
Intrusives	Synorogenic, 1915±7 Ma Ruoppapalo granitoid intrusion (the granodiorite) and the related albitites, clearly predate gold mineralisation: interpreted from [1].				
METAMORPHISM					
Metamorphic grade	Greenschist facies [1].				
STRUCTURAL SETTING					
Structural style	Brittle(-ductile) [1].				
Closest major shear	Kuotko Main Shear <1 km to the NW from the deposit [1].				
Controlling structure	Contact zone between the Ruoppapalo synorogenic granitoid intrusion and its country rocks [1,2].				
Veins	Quartz-carbonate ± pyrite [1].				
ALTERATION					
General alteration	Bleaching [1].				
TIMING	Mineralisation post-dates the Ruoppapalo granitoid and is, hence, younger than 1915±7 Ma.				
GENETIC MODEL	Clearly epigenetic, "mesothermal" mineralisation with a distinct structural control [1].				
FIGURES	[2]: Regional geology map.				

References

1. Härkönen, I. 1998. Personal communications on 24/08/1998 and 17/9/1998.
2. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.

Name	***Saattopora***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Lapland **Belt** Kittilä
Map sheet	2741 04 **X coordinate** 7522830 **Y coordinate** 2517400
Municipality	Kittilä
Nearest town, access	40 NW km of Kittilä, 200 km NNW of Rovaniemi. 10 km to a sealed road, a gravel road to the mine site.
MINING	
Mining concession no.	2288/1a.
Present holder	Outokumpu Oyj 1974-.
Status of development	Open pit and underground, mining ceased.
When mined	1988-1995 [2].
Resources	Original resource estimate (1988) was 0.68 Mt at 3.6 ppm Au and 0.3% Cu [9,10,11].
Total production	6279 kg Au [1,2], 5177 t Cu [2].
Extent of mineralisation	The two main lodes are up to 10 wide and 250-250 m long [5,6].
Lodes	Two main lodes, the northern A lode and the southern B lode [2,5,6,7], and a smaller C lode [8].
EXPLORATION	
Discovery	By Outokumpu on 1985 [2,5,6,9,10,11]: A base metal mineralisation adjacent to the gold deposit was discovered 1970 by bedrock mapping and diamond drilling. The gold deposit was detected on 1985 by reanalysing Au of the earlier drill core.
Exploration history	Outokumpu (1960's to 1995) [2,5,6,9,10,11,13]: Started as base metal exploration [2,11,12] which continued as Au exploration in the 1980's: bedrock mapping, till stratigraphy and geochemistry, trenching, diamond, percussion and RC drilling, ground magnetic, slingram and VLF surveys, mineralogical and geochemical studies.
Drilling	Outokumpu (1964-1994) [2,5]: Saattopora and the adjacent areas: diamond drilling 58.7 km, percussion drilling 27.2. km, RC drilling 0.7 km. Diamond drilling at site in 20 x 20 m grid which was filled by 5 x 5 m grid of percussion drilling during mining [6].
Elements analysed	Au, Ag, Co, Cu, Ni, Pb, Zn by AAS, S by Leco (by Outokumpu). By GFAAS: Ag, Au, Co, Cu, Mo, Ni, Pb, Te, Zn, by fire assay: Au, by ICP: Ag, Al, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Sc, Si, Sr, Th, Ti, V, Y, Zn [7].
Economic evaluations	Feasibility study by Outokumpu 1988-1989 [5].
Geophysical response	No response detected [2,5,6,9,10,11,13].
Primary dispersion	A distinct Au anomaly to the south of the base-metal deposit, i.e. enveloping the gold deposit [12].
Exploration geologist(s) in charge	Outokumpu: Tuomo Korkalo.
ORE	
Siting of gold	Mainly free native gold in quartz-carbonate veins and in their immediate wallrock, chiefly associated with quartz, carbonates and sulphides, locally also with U-Th oxides [10].
Fineness	<1% Ag, traces of Cu and As [2,10].
Major opaques	Pyrite, pyrrhotite [2,10].
Minor opaques	Chalcopyrite, gersdorffite, rutile, pentlandite, tucholite, uraninite, bismuthite, niccolite and gold [2,10,12].
Gangue	Quartz, Fe dolomite, ankerite, albite, tourmaline [2,10,12].
Ore composition	Average mined ore: 3.29 ppm Au, 0.28% Cu [2]. 15 analyses of ore: 45.8% SiO2, 10.24% Al2O3, 0.11% MnO, 7.33% CaO, 0.26% K2O, 0.033% Cr2O3, 7.76 ppm Au, 190 ppm Co, 4890 ppm Cu [10]. Diamond-drill core, A-lode [7]: 9.10 ppm Au, 0.021 ppm Ag, 28 ppm As, 621 ppm B, 84 ppm Ba, 0.2 ppm Bi, 88 ppm Co, 1980 ppm Cu, 7.0 ppb Hg, <1.0 ppm Mo, 346 ppm Ni, <2 ppm Pb, 13 ppm Rb, 45800 ppm S, 0.2 ppm Sb, 1.16 ppm Se, 57 ppm Sr, 1.40 ppm Te, <0.5 ppm Th, 9.9 ppm U, 270 ppm V, 27 ppm W, 23 ppm Zn, 51 ppm Zr; 33.8% SiO_2, 0.79% TiO_2, 7.37% Al_2O_3, 16.8% Fe_2O_3, 6.80% MgO, 10.3% CaO, 3.31% Na_2O, 0.36% K_2O, 0.06% P_2O_5, 6.43% LOI. Diamond-drill core, B-lode [7]: 2.90 ppm Au, 0.302 ppm Ag, 570 ppm As, 216 ppm B, 167 ppm Ba, 2.7 ppm Bi, 248 ppm Co, 8350 ppm Cu, 20.0 ppb Hg, 2.0 ppm Mo, 1000 ppm Ni, 14 ppm Pb, 17 ppm Rb, 64300 ppm S, 0.4 ppm Sb, 6.60 ppm Se, 52 ppm Sr, 1.80 ppm Te, 4.8 ppm Th, 22.9 ppm U, 130 ppm V, 7 ppm W, 53 ppm Zn, 67 ppm Zr; 31.8% SiO_2, 0.44% TiO_2, 7.02% Al_2O_3, 17.3% Fe_2O_3, 6.52% MgO, 10.2% CaO, 2.84% Na_2O, 0.30% K_2O, 0.034% P_2O_5, 10.1% LOI.
Enriched elements	Au, Ag, As, B, Bi, CO_2, Cu, S, Se, Te, U, W [2,7].
Stable isotope data	$\delta^{34}S$ = -8.7 – +4.0‰ in sulphides in the area; this range also includes the syngenetic base-metal deposit [12].
Pb isotope data	[8]: Mantle-derived lead? Sulphides from Au concentrate give scattered Pb-Pb ages of 1907-1985 Ma. Linear Pb-Pb ages from sulphides and carbonates give 1894±46 Ma.
GEOLOGY	
Major host rocks	Intermed., albitised metasedimentary and -pyroclastic rocks [2,5,12].
Minor host rocks	Metakomatiites [2,12].

Geological setting The ore is chiefly hosted by a sequence of intensely altered, partially volcanogenic, metasedimentary rocks (graphitic phyllites) and equally altered, metapyroclastic rocks (intermediate to mafic tuffs and tuffites) which at Saattopora, due to their early alteration, are commonly called albitites [2,3,5,10,12]. Footwall: komatiite, hangingwall: graphitic phyllite [10]. The rock sequence is part of the >2050 Ma Savukoski Group of the Palaeoproterozoic Central Lapland Greenstone Belt [4].

Intrusives Dolerites which predate all alteration and mineralisation [12].

METAMORPHISM

Metamorphic grade Lower- to mid-greenschist facies [3].

Metamorphic mineral assemblage Metakomatiites: talc-chlorite ± carbonate [12].
Dolerites: albite-actinolite-epidote-titanite [12].
Phyllites: quartz-albite-chlorite ± biotite, sericite, graphite [12].

STRUCTURAL SETTING

Structural style Brittle(-ductile) [2,3,12].

Closest major shear The Sirkka Line which is here E-W trending and about 250 m wide [2,4,10].

Controlling structure The Sirkka Line and its subsidiary, parallel brittle-ductile structures [2,4,10].

Ore fabric Massive, intensely brecciated [2,3,12].

Veins A few millimetres to several metres thick quartz-carbonate veins; these are chiefly N-S trending, but there also are E-W trending, conjugate(?), veins with similar mineralogy as the N-S trending veins [2,10].

ALTERATION

General alteration [2,3,12]: Two apparent major stages of alteration: 1) Albitisation and part of carbonation may have preceded gold mineralisation, taken place before regional deformation, as a synvolcanic, spilitic stage of alteration, related to the formation of the syngenetic base-metal mineralisation in the phyllites. 2) Sericitisation, sulphidation and main carbonation, with formation of abundant quartz veins, are most probably related to the syn-peak metamorphic gold mineralisation.

Distal alteration Metakomatiites: talc-chlorite-carbonate [12].

TIMING Probably, during 1870-1900 Ma [8], from the following data: U-Pb concordia age for monazite and thucolite 1781±18 Ma and for rutile 1684±5 and 1707±8 Ma, Pb-Pb age for pyrrhotite 1662±5-1704±4 Ma; the post-1.87 Ga ages probably reflect post-mineralisation heating related to postorogenic granites [8]. Sulphides from Au concentrate give scattered Pb-Pb ages of 1907-1985 Ma [8]. Linear Pb-Pb ages from sulphides and carbonates give 1894±46 Ma [8].

GENETIC MODEL During mineralisation, the Au-bearing veins were preferably developed in the most compact lithological units, chiefly in albitised rocks [2]. Probably, albitisation predated gold mineralisation and produced competent units which were structurally favourable for gold mineralisation [3].

Post-mineralisation modifications

Heating related to post-orogenic granites has reset U-Pb and Pb-Pb ages in monazite, rutile, thucolite and pyrrhotite [8].

FIGURES [2]: Local geology map and a cross section map.
[4]: Regional geology map.

References

1. Anttonen, R. 1998. Personal communication 15/02/1998.
2. Korvuo, E. 1997. The Saattopora gold ore and the Pahtavuoma Cu-Zn-U occurrences in the Kittilä region, northern Finland. In: E. Korkiakoski & P. Sorjonen-Ward (eds) Ore deposits of Lapland in northern Finland and Sweden. Geological Survey of Finland, Guide 43, 21-25.
3. Eilu, P. 1997. Orogenic lode-gold deposits: Notes to accompany samples from deposits located on the Fennoscandian Shield. University of Turku, Department of Geology and Mineralogy, Publication 35, 1st edition. 14 p
4. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
5. Anttonen, R., Korkalo, T. & Oravainen, H. 1989. Lapin kultaa Saattoporan kaivoksesta. Summary: Gold from Lapland - Outokumpu Oy's Saattopora mine. Vuoriteollisuus 47, 104-108.
6. Wyllie, R. J. M. 1989. Saattopora. Outokumpu opens Lapland gold mine, first new Finnish mine in years. Engineering and Mining Journal, June 1989, 40-43.
7. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
8. Mänttäri, I. 1995. Lead isotope characteristics of epigenetic gold mineralization in the Palaeoproterozoic Lapland greenstone belt, northern Finland. Geological Survey of Finland Bulletin, 381. 70 p.
9. Anttonen, R. 1992. Outokumpu's experiences from exploitation of gold ores. Bidjovagge Mine, Saattopora Mine. Geological Survey of Finland, unpublished report M10.2/-92/1. 5 p. (in Finnish)
10. Hugg, R. 1991. Saattoporan kultamalmiesiintymästä. Geological Survey of Finland, unpublished report M10.2/-92/1. 5 p. (in Finnish)
11. Korvuo, E. 1992. Saattoporan kaivos: Kaivospäätös ja sitä seuranneet toimenpiteet sekä malmivarat. Geological Survey of Finland, unpublished report M10.2/-92/1. 4 p. (in Finnish)
12. Lehtinen, M. 1987. Kittilän tutkimusalue: Saattopora. In: H. Papunen (ed.) Lapin vulkaniittien tutkimusprojekti. Loppuraportti. Department of Geology, University of Turku, unpublished report. 463 p. (in Finnish)
13. Wennervirta, H. 1972. Moreenin pintatutkimus, Muusanlammet, Kittilä. Outokumpu Oy, unpublished report 062/2741 07/HW/72. 2 p. (in Finnish)

Name	***Sirkka kaivos***				
GENETIC TYPE	Orogenic ‘mesothermal’.				
LOCATION					
Geological domain	Lapland	**Belt**	Kittilä		
Map sheet	2741 10	**X coordinate**	7525500	**Y coordinate**	2531050
Municipality	Kittilä				
Nearest town, access	20 km NNW from Kittilä. 3 km from a sealed road, a gravel road to the area.				
MINING					
Exploration licence no.	6465/1.				
Mining concession no.	622/1-5.				
Present holder	SES Finland.				
Previous holders	Atri Oy (1939-1953), Vuoksenniska Oy (1953-1966), Outokumpu Oy (1966-1978).				
Status of development	Prospect.				
Extent of mineralisation	The detected lodes are in a E-W trending domain 1.5 km long and 100-200 m wide [4].				
Lodes	Six gold-bearing lodes along the ENE-WSW strike of the Sirkka Line shear zone: 40-200 m long, 1-6 m wide, apparently subvertical, all open at depth of 30-60 m [4].				
EXPLORATION					
Discovery	Atri Oy 1939 [2,3,6]: auriferous boulders in adjacent lake shores led the prospectors to the mineralised area.				
Exploration history	Atri Oy (1939-1953) [2,3,4,6]: bedrock mapping, trenching, ground magnetic and electromagnetic survey, diamond drilling; most of data only extends to the depth of 50 m.				
	Vuoksenniska (1953-1966) [2,4,6]: till geochemical survey, underground exploration, pilot plant tests.				
	Outokumpu (1966-1978) [2,3,4,6,7,8]: till geochemical survey, bedrock mapping, diamond drilling, detailed mineralogical (petrography and microprobe investigations) and geochemical studies.				
	SES (1997-) [5]: Trenching and channel sampling, RC drilling.				
Drilling	Atri Oy (1939-1953) [2,8]: about 110 diamond-drill holes.				
	Vuoksenniska (1955-1956) [6]: about 70 diamond-drill holes.				
	Outokumpu (1967) [2,3]: four diamond-drill holes, total 572 m.				
	SES 1997: a few RC-drill holes.				
Elements analysed	Major elements, Ag, As, Ba, Co, Cu, Ni, Pb, S, and Zn by XRF [4]. Gold and Ag analysed by AAS and GFAAS?				
Economic evaluations	Feasibility study by Vuoksenniska 1955-1956 [2].				
Exploration geologist(s) in charge					
	Atri: Birger Ohlsson, Outokumpu: Pauli Isokangas; SES: Alf Björklund.				
ORE					
Siting of gold	Dominantly native gold which chiefly occurs associated with gersdorffite and arsenopyrite (mostly as inclusions) [2,4,6,7,8]. Grain size of gold is up to 0.05 mm [4].				
Major opaques	Pyrite, pyrrhotite, chalcopyrite [2,4,6,7,8].				
Minor opaques	Ilmenite, pentlandite, rutile, graphite, Ag pentlandite, sphalerite, mackinawite, violarite, gersdorffite, rutile, cobaltite, gold, melnikovite [2,4,6,7,8].				
Gangue	Quartz, ankerite, siderite or Fe dolomite, tourmaline [2,4,6,8].				
Ore composition	Bulk ore samples: 1-30 ppm Au, 1-200 ppm Ag, 1100-2100 ppm Co, 3400-6600 ppm Cu, 5200-12700 ppm Ni [2].				
Enriched elements	Ag, As, Au, Co, CO_2, Cu, K, Ni, Rb, S [2,3,4,6].				
GEOLOGY					
Major host rocks	Mafic lavas, tuffs and tuffites [2,4,6].				
Minor host rocks	Metakomatiite and graphitic phyllite [2,3,4,6].				
Geological setting	The deposit is in a E-W trending sequence of mafic metavolcanic rocks, metatuffites, metakomatiites and graphitic phyllites [1,4] belonging to the Matarakoski Formation of the >2050 Ma Savukoski Group of the Palaeoproterozoic Central Lapland Greenstone Belt [1].				
Intrusives	Sub-conformable dolerites and related(?) intermediate and felsic dikes which all predate gold mineralisation-related alteration [4,6].				
METAMORPHISM					
Metamorphic grade	The mineral assemblages described in [2,4,8] indicate mid- to upper-greenschist facies conditions.				
Metamorphic mineral assemblage	Ultramafic rocks: talc-chlorite-magnesite [4]. Mafic rocks: albite-actinolite-epidote-titanite ± chlorite [4,6]. Metatuffites: quartz-albite-chlorite-actinolite-ilmenite or titanite ± sericite, biotite, epidote [6]. Metasedimentary rocks: albite-quartz-sericite-chlorite-biotite ± graphite, pyrrhotite [4].				
STRUCTURAL SETTING					
Structural style	Brittle [2,3,4].				
Closest major shear	The Sirkka Line [1].				

Controlling structure The Sirkka Line [1].

Ore fabric Granoblastic, fractured, massive; pyrite, arsenopyrite, gersdorffite and cobaltite are commonly idiomorphic [4].

Veins Quartz-carbonate, chalcopyrite-pyrrhotite-quartz ± albite and carbonate, arsenopyrite-carbonate, arsenopyrite-pyrrhotite, gersdorffite-carbonate, and chalcopyrite-pyrite-quartz-carbonate veins which are, on average 10-20 cm wide [2,3,4]. The arsenopyrite- and gersdorffite-bearing veins contain small amounts of gold, other sulphides, quartz and tourmaline [4,7].

ALTERATION

General alteration [6]: Two apparent, major stages of alteration: 1) Albitisation and part of carbonation may have preceded gold mineralisation, taken place before regional deformation, as a synvolcanic, spilitic stage of alteration. 2) Sericitisation, sulphidation and part of carbonation, with formation of abundant quartz veins, are probably related to the syn-peak metamorphic gold mineralisation.

Proximal alteration Intense carbonation, sulphidation [6].

GENETIC MODEL Clearly epigenetic, “mesothermal” mineralisation with a distinct structural control [2,3,4,6]. Although, the reference [4] is written to support a late-magmatic model.

FIGURES [1]: Regional geology map.
[4]: Three local geology maps.

References

1. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
2. Inkinen, O. 1985. Kittilän Sirkan kulta-kupariesiintymästä. Summary: Gold-copper occurrence at Sirkka, Kittilä. Geologi 37 (1), 8-11.
3. Isokangas, P. 1967. Kaivospiirien Sirkka I-V hylkäämisilmoitus. Outokumpu Oy, unpublished report M17/Ktä-58-67/1. 2 p. (in Finnish)
4. Vesanto, J. 1978. Sirkan malmi ja sitä ympäröivä kallioperä. Unpublished MSc thesis, Department of Geology, University of Oulu. 89 p. (in Finnish)
5. Björklund, A. 1998. Personal communication 07/08/1998.
6. Lehtinen, M. 1987. Kittilän tutkimusalue: Sirkka. In: H. Papunen (ed.) Lapin vulkaniittien tutkimusprojekti. Loppuraportti. Department of Geology, University of Turku, unpublished report. 85-96. (in Finnish)
7. Hänninen, E. 1977. Kittilän Sirkan malmityypeistä. Outokumpu O, unpublished report 070/2741 10B/EH/77. (in Finnish)
8. Mikkola, A. & Sandstöm, G. 1964. Kittilän malmitutkimukset. Raportti Sirkan malmista. Outokumpu Oy, Malminetsintä, unpublished report. 20 p. (In Finnish)

Name	***Sirkka W***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kittilä
Map sheet	2741 10 **X coordinate** 7525250 **Y coordinate** 2525000
Municipality	Kittilä
Nearest town, access	21 km NNW from Kittilä. 4 km from a sealed road, a gravel road to the area.
MINING	
Exploration licence no.	3912/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oy (1977-1987).
Status of development	Prospect.
Best sections	11.6 m at 0.5 ppm Au and 0.5% Cu [5].
EXPLORATION	
Discovery	Outokumpu 1977 [5]: Diamond drilling into local geochemical anomalies in till.
Exploration history	Atri Oy (1939-1953) [3,4,6]: bedrock mapping, trenching, ground magnetic and electromagnetic survey in the area. Outokumpu (1977-1987) [5,6]: Till geochemical survey, bedrock mapping, ground magnetic and slingram survey, trenching, diamond drilling.
Drilling	Outokumpu (1987) [5]: 5 diamond-drill holes, total 450 m.
Elements analysed	By GFAAS: Ag, Au, Co, Cu, Mo, Ni, Pb, Te, Zn, by fire assay: Au, by ICP: Ag, Al, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Sc, Si, Sr, Th, Ti, V, Y, Zn [1].
Secondary dispersion	Regional As, Cr, Cu and Ni anomalies cover the area [5].
Exploration geologist(s) in charge	Atri: Birger Ohlsson, Outokumpu: Risto Anttonen, Rauno Hugg.
ORE	
Gangue	Quartz, ankerite, siderite [3].
Ore composition	Diamond-drill core, metakomatiite(?) [1]: 1.80 ppm Au, 0.076 ppm Ag, 54 ppm As, 5.7 ppm B, 111 ppm Ba, 2.8 ppm Bi, 42 ppm Co, 241 ppm Cu, 5 ppb Hg, <1 ppm Mo, 622 ppm Ni, 7 ppm Pb, 51 ppm Rb, 21200 ppm S, 1.1 ppm Sb, 0.24 ppm Se, 30 ppm Sr, 0.390 ppm Te, <0.5 ppm Th, 2.2 ppm U, 120 ppm V, <0.5 ppm W, 59 ppm Zn, 21 ppm Zr; 19.9% SiO_2, 0.24% TiO_2, 2.14% Al_2O_3, 26.1% Fe_2O_3, 14.8% MgO, 8.17% CaO, 0.11% Na_2O, 0.84% K_2O, 0.007% P_2O_5, 19.8% LOI.
Enriched elements	As, Au, Bi, CO_2, Cu, K, Rb, S, Sb, Te [1,4,5].
GEOLOGY	
Major host rocks	Metasedimentary(?) rocks [3].
Minor host rocks	Metakomatiite(?) [1,3].
Geological setting	The host rocks are in the sequence of chiefly metasedimentary rocks of the Matarakoski Formation of the >2050 Ma Savukoski Group of the Palaeoproterozoic Central Lapland Greenstone Belt [2].
METAMORPHISM	
Metamorphic grade	Greenschist facies [3].
STRUCTURAL SETTING	
Structural style	Brittle [3,4,5].
Closest major shear	The Sirkka Line [2].
Controlling structure	The Sirkka Line [2].
Veins	Mineralised quartz-carbonate veins form networks [3,4,5].
ALTERATION	
General alteration	Early(?) albitisation and carbonation, synvolcanic and/or early-metamorphic, overprinted by syn-gold sericitisation, sulphidation and carbonation [3,4,5].
GENETIC MODEL	Clearly epigenetic, “mesothermal” mineralisation with a distinct structural control [4,5].
FIGURES	[2]: Regional geology map. [5]: Drilling profiles with Au and Cu data.

References

1. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
2. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
3. Inkinen, O. 1985. Kittilän Sirkan kulta-kupariesiintymästä. Summary: Gold-copper occurrence at Sirkka, Kittilä. Geologi 37 (1), 8-11.
4. Isokangas, P. 1967. Kaivospiirien Sirkka I-V hylkäämisilmoitus. Outokumpu Oy, unpublished report M17/Ktä-58-67/1. 2 p. (in Finnish)
5. Hugg, R. 1987. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Kittilä, Sirkka, kaiv. rek. n:o 3912/1. Outokumpu Oy, unpublished report 080/2741 10/REH/1987. 2 p. (in Finnish)
6. Vesanto, J. 1978. Sirkan malmi ja sitä ympäröivä kallioperä. Unpublished MSc thesis, Department of Geology, University of Oulu. 89 p. (in Finnish)

Name	***Soretialehto***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Lapland **Belt** Kittilä
Map sheet	2734 03 **X coordinate** 7518300 **Y coordinate** 2549700
Municipality	Kittilä
Nearest town, access	15 km NE from Kittilä. 5 km from a sealed road, 1 km from a gravel road.
MINING	
Exploration licence no.	6443/1.
Present holder	Part of the area: Saxo Oy (1993-), another part: Terra Mining.
Previous holders	Geological Survey of Finland (GTK) (1977-1993).
Status of development	Prospect.
Resources	0.013 Mt at 3.5 ppm Au [4].
Total in-situ gold	40 kg Au [4].
Best sections	8 m at 3-4 ppm Au [4].
Lodes	Auriferous quartz-dolomite-albite-pyrite vein-network zones which have a NE-SW trend [4,6].
EXPLORATION	
Exploration history	Atri Oy (late 1940's) [2,4]: Bedrock mapping, ground magnetic and electromagnetic survey. GTK (1977-1993) [2,4,5,7,8]: High- and low-altitude airborne magnetic, electromagnetic, gravimetric and radiometric survey, ground magnetic, gravimetric, slingram, VLF-R and IP survey, regional and local till stratigraphy and geochemistry, stream sediment geochemical survey, bedrock mapping, trenching, diamond and RC drilling, systematic percussion drilling into bedrock surface.
Elements analysed	Au by GFAAS; Co, Cu, Mn, Ni, Pb, Zn, W by ICP [2,6].
Secondary dispersion	Regional As, Co, Cu and Mo anomalies in till cover the area [2,5]. Local Au, As, Co, Cu, Mo and W anomalies in till [2,5].
Exploration geologist(s) in charge	GTK: Veikko Keinänen.
ORE	
Siting of gold	Native gold as inclusions in pyrite and as free grains associated with vein quartz [7].
Fineness	91.6% Au, 6.9% Ag, 1.9% Se [8].
Major opaques	Pyrite [4,6,7,8].
Minor opaques	Chalcopyrite, galena, gersdorffite, ullmannite, gold [4,6,8], in phyllite also arsenopyrite and in ultramafic rocks also millerite and vaesite [8].
Gangue	Quartz, Fe dolomite, scheelite [1,2,5,8].
Enriched elements	Au, As, CO_2, K, S, W [8].
GEOLOGY	
Major host rocks	Metakomatiite [6,7]
Minor host rocks	Graphitic phyllite, felsic dykes [4,7].
Geological setting	The host rocks are in a sequence of basaltic and komatiitic metavolcanic rocks and fine-grained metasedimentary rocks of the >2050 Ma Savukoski Group of the Palaeoproterozoic Central Lapland Greenstone Belt [3].
Intrusives	Felsic dikes, which are altered and mineralised, predate gold mineralisation [4].
METAMORPHISM	
Metamorphic history	Regional metamorphism took place at ca. 1.9 Ga [7].
Metamorphic grade	Lower- or mid greenschist facies [7].
Metamorphic mineral assemblage	Ultramafic rocks: talc-chlorite-calcite [4].
STRUCTURAL SETTING	
Structural style	Brittle.
Closest major shear	More than 150 km long, E-W to NW-SE trending shear zone, the Sirkka Line, [2,6].
Controlling structure	The deposit is in the western flank of the Sirkka Line, which here has a NW-SE trend, in an area where a NE-SW shear/fault zone cuts across the Sirkka Line [6,7]. The local control is, possibly, a minor shear zone at the contact between ultramafic rocks and graphitic phyllite [4].
Veins	Auriferous quartz-dolomite-albite-pyrite vein-network zones [4,6].
ALTERATION	
General alteration	Synvolcanic and/or early-metamorphic, pre-gold albitisation and partial carbonation of large areas was followed by synorogenic, structurally-controlled carbonation, sericitisation and gold mineralisation [2,6,7].
Proximal alteration	Extent about 30 x 100 m at surface [4]. Metakomatiite: quartz-Fe dolomite-magnesite-fuchsite-pyrite [4,8]. Felsic dikes: quartz-albite-sericite ± pyrite [4].

Distal alteration	Metakomatiite: talc-carbonate-chlorite [4].
TIMING	The gold mineralisation in the Kuotko-Kiistala-Soretiavuoma area, which includes the Soretialehto mineralisation, probably took place between 1852-1890 Ma [1].
GENETIC MODEL	Clearly epigenetic, “mesothermal” [7,8]. The shear zone at the contact between ultramafic rocks and graphitic phyllite formed the local channel for fluid flow. Carbonated komatiite was brecciated as it wasthe more competent unit at site and, hence, was more intensely veined and forms the main host to ore [4].
FIGURES	[3]: Regional geology map.

References

1. Mänttäri, I. 1995. Lead isotope characteristics of epigenetic gold mineralization in the Palaeoproterozoic Lapland greenstone belt, northern Finland. Geological Survey of Finland, Bulletin 381. 70 p.
2. Keinänen, V., Johansson, P. & Lehmuspelto, P. 1988. Soretiavuoman volframi- ja kultatutkimuksista. Annales Universitatis Turkuensis, Sarja C, Tom. 67, 69-77. (in Finnish)
3. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
4. Keinänen, V. 1997, 1998. Personal communications on 24/11/1997 and 18/8/1998.
5. Johansson, P., Keinänen, V. & Lehmuspelto, P. 1986. Geochemical exploration of tungsten in glaciogenic deposits in Soretiapulju, western Finnish Lapland. Proceedings in Areas of Glaciated Terrain. Symposium held in Kuopio, 1 and 2 September 1986. London: The Institution of Mining and Metallurgy, 61-67.
6. Keinänen, V. & Hulkki, H. 1992. Main features of the three geochemically different gold mineralizations in Soretiavuoma, Finnish Lapland. 20:e Nordiska Geologiska Vintermötet, Reykjavik. Abstracts. p. 96.
7. Keinänen, V. 1994. Shear zone-related Soretialehto gold occurrence in green carbonate rocks in the Central Lapland Greenstone Belt, Kittilä, Finnish Lapland. 21:a Nordiska Geologiska vintermötet, Luleå. Abstracts. p. 99.
8. Riikonen, S. 1997. Kittilän kromimarmorien mineralogia. Unpublished MSc thesis, Department of Geology, University of Oulu. 61 p. (in Finnish)

Name	***Soretiavuoma N***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Lapland **Belt** Kittilä
Map sheet	2734 01 **X coordinate** 7520100 **Y coordinate** 2549500
Municipality	Kittilä
Nearest town, access	17 km NE from Kittilä. 6 km from a sealed road, 1 km from a gravel road.
MINING	
Exploration licence no.	3761/1, 3821/1, 5290/1, 6727/2.
Present holder	Terra Mining.
Previous holders	Geological Survey of Finland (GTK) (1977-1997).
Status of development	Prospect.
Best sections	3 m at 5 ppm Au, 1.5 m at 5.1 ppm Au, 1.1 m at 48 ppm Au, 1 m at 23.5 ppm Au, several 1-3 m sections at 1-3 ppm Au [5,10,11].
Extent of mineralisation	Width up to 80 m, length 200 m [10].
EXPLORATION	
Discovery	By GTK during the late 1980's [5].
Exploration history	Atri Oy (late 1940's) [3]: Bedrock mapping, ground magnetic and electromagnetic survey. GTK (1977-1997) [1,3,5,6,7,8,10,11]: High- and low-altitude airborne magnetic, electromagnetic, gravimetric and radiometric survey, ground magnetic, gravimetric, slingram, VLF-R and IP survey, regional and local till stratigraphy and geochemistry, stream sediment geochemical survey, bedrock mapping, trenching, diamond and RC drilling, systematic percussion drilling into bedrock surface.
Drilling	GTK [3,5,10,11]: 16 diamond-drill holes, total 1417 m, and 20 RC-drill holes, total 960 m.
Elements analysed	By GFAAS: Ag, Au, Co, Cu, Mo, Ni, Pb, Te, Zn, by fire assay: Au, by ICP: Ag, Al, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Sc, Si, Sr, Th, Ti, V, Y, Zn [9].
Geophysical response	An IP anomaly, and a non-magnetic domain within a positive magnetic anomaly [5].
Secondary dispersion	Regional As, Co, Cu and Mo anomalies in till cover the area [3,6]. Local Au, As, Co, Cu, Mo and W anomalies in till [3,6]. In addition, K anomalies in till in the area of komatiites [10].
Exploration geologist(s) in charge	
	GTK: Veikko Keinänen.
ORE	
Siting of gold	Native gold grains chiefly in fractures and as inclusions in pyrite [1].
Major opaques	Pyrite [1,7,11].
Minor opaques	Chalcopyrite, pyrrhotite, arsenopyrite, galena, bismuthinite, millerite, violarite, gold [1,7,11].
Gangue	Quartz, ankerite/dolomite, scheelite [1,3,5,6,7].
Ore composition	Diamond-drill core, metakomatiite [9]: 3.70 ppm Au, 1.40 ppm Ag, 1100 ppm As, 15 ppm B, 147 ppm Ba, 6.2 ppm Bi, 428 ppm Co, 1920 ppm Cu, 20 ppb Hg, <1 ppm Mo, 2380 ppm Ni, 52 ppm Pb, 10 ppm Rb, 61400 ppm S, 1.1 ppm Sb, 0.92 ppm Se, 92 ppm Sr, 0.420 ppm Te, <0.5 ppm Th, 0.2 ppm U, 150 ppm V, 4 ppm W, 91 ppm Zn, 24 ppm Zr; 24.7% SiO_2, 0.41% TiO_2, 4.65% Al_2O_3, 17.3% Fe_2O_3, 16.5% MgO, 7.09% CaO, 1.02% Na_2O, 0.15% K_2O, 0.027% P_2O_5, 18.8% LOI.
Enriched elements	Au, Ag, As, Bi, CO_2, Cu, K, Pb, S, Sb, Se, Te, W [3,7,9,10].
Pb isotope data	Pb-Pb ages for chalcopyrite, arsenopyrite, pyrite and carbonates range 1859-1890 Ma [2].
GEOLOGY	
Major host rocks	Metakomatiite [1,5,7,10]
Minor host rocks	Metabasalt [10].
Geological setting	The mineralisationis in a sequence of basaltic and komatiitic metavolcanic rocks and fine-grained metasedimentary rocks of the >2050 Ma Savukoski Group of the Palaeoproterozoic Central Lapland Greenstone Belt [4].
Intrusives	Minor pre-gold, altered, felsic dikes [5].
METAMORPHISM	
Metamorphic history	Regional metamorphism took place at ca. 1.9 Ga [8].
Metamorphic grade	Lower- or mid-greenschist facies [8].
Metamorphic mineral assemblage	Ultramafic rocks: talc-chlorite-calcite [5,10].
STRUCTURAL SETTING	
Structural style	Brittle(-ductile) [5].
Closest major shear	More than 150 km long, NNW-SSE to NW-SE trending shear zone, the Sirkka Line [3,7].
Controlling structure	The deposit is in the central part of the Sirkka Line, which here has a NW-SE trend, in area where a NW-SE fracture zone cuts across the Sirkka Line [7].
Ore fabric	Granoblastic [5].

Veins	Auriferous quartz-dolomite ± albite, pyrite, chalcopyrite veins form networks [5,7].
ALTERATION	
General alteration	Synvolcanic and/or early-metamorphic, pre-gold albitisation and partial carbonation of large areas was followed by synorogenic, structurally-controlled carbonation and gold mineralisation [3,7]. Apparently, no sericitisation or biotitisation! [5].
Proximal alteration	Metakomatiite: quartz-Fe dolomite-magnesite-pyrite [5].
Intermediate alteration	Metakomatiite: chlorite-talc-Fe dolomite-quartz [5].
Distal alteration	Metakomatiite: chlorite-talc-carbonate - a soapstone-like rock [5].
TIMING	Pb-Pb ages for chalcopyrite, arsenopyrite, pyrite and carbonates range 1859-1890 Ma [2]. The gold mineralisation in the Kuotko-Kiistala-Soretiavuoma area probably took place between 1852-1890 Ma [2].
GENETIC MODEL	Clearly epigenetic, "mesothermal" mineralisation with a distinct structural control [5,7,8,9].
FIGURES	[4]: Regional geology map.

References

1. Härkönen, I. & Keinänen, V. 1989. Exploration of structurally controlled gold deposits in the Central Lapland greenstone belt. Current Research 1988, Geological Survey of Finland, Special Paper 10, 79-82.
2. Mänttäri, I. 1995. Lead isotope characteristics of epigenetic gold mineralization in the Palaeoproterozoic Lapland greenstone belt, northern Finland. Geological Survey of Finland, Bulletin 381. 70 p.
3. Keinänen, V., Johansson, P. & Lehmuspelto, P. 1988. Soretiavuoman volframi- ja kultatutkimuksista. Annales Universitatis Turkuensis, Sarja C, Tom. 67, 69-77. (in Finnish)
4. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
5. Keinänen, V. 1997, 1998. Personal communications on 24/11/1997, 18/8/1998 and 23/12/1998.
6. Johansson, P., Keinänen, V. & Lehmuspelto, P. 1986. Geochemical exploration of tungsten in glaciogenic deposits in Soretiapulju, western Finnish Lapland. Proceedings in Areas of Glaciated Terrain. Symposium held in Kuopio, 1 and 2 September 1986. London: The Institution of Mining and Metallurgy, 61-67.
7. Keinänen, V. & Hulkki, H. 1992. Main features of the three geochemically different gold mineralizations in Soretiavuoma, Finnish Lapland. 20:e Nordiska Geologiska Vintermötet, Reykjavik. Abstracts. p. 96.
8. Keinänen, V. 1994. Shear zone-related Soretialehto gold occurrence in green carbonate rocks in the Central Lapland Greenstone Belt, Kittilä, Finnish Lapland. 21:a Nordiska Geologiska vintermötet, Luleå. Abstracts. p. 99.
9. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
10. Keinänen, V. 1997. Tutkimustyöselostus Kittilän kunnassa valtausalueella Soretiavuoma 3 (kaiv.rn:o 5290/1) suoritetuista malmitutkimuksista. Geological Survey of Finland, unpublished report M06/2734/- 97/1/10. 8 p. (in Finnish)
11. Keinänen, V. 1990. Tutkimustyöselostus valtausalueiden Soretiajärvi 1, kaiv.rn: 3761/2, sekä Soretiavuoma 1 (kaiv.rn: 3761/1) ja 2 (kaiv.rn: 3821/1) malmitutkimuksista vuosina 1984-89. Geological Survey of Finland, unpublished report M06/2734/-90/1/10. 3 p. (in Finnish)

Name	***Sukseton***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kittilä
Map sheet	2744 04 **X coordinate** 7556000 **Y coordinate** 2556700
Municipality	Kittilä
Nearest town, access	50 km NE from Kittilä. 58 km from a sealed road, 1 km from a gravel road.
MINING	
Present holder	Outokumpu Oyj(?).
Status of development	Prospect.
Best sections	4.6 m at 2.8 ppm Au [3,4].
EXPLORATION	
Discovery	By Outokumpu 1981 [3].
Exploration history	Outokumpu (1970's-1980's) [3,4]: till geochemical survey, ground geophysical surveys, trenching, diamond drilling, petrographic and lithogeochemical investigations.
Drilling	Outokumpu: 24 diamond-drill holes, total 3381 m [3,4].
Elements analysed	By GFAAS: Ag, Au, Co, Cu, Mo, Ni, Pb, Te, Zn, by fire assay: Au, by ICP: Ag, Al, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Sc, Si, Sr, Th, Ti, V, Y, Zn [1].
Exploration geologist(s) in charge	Outokumpu: Urpo Kuronen.
ORE	
Siting of gold	Chiefly associated with silicates and carbonates, less with sulphides [3].
Major opaques	Pyrite, pyrrhotite [3].
Minor opaques	Chalcopyrite, arsenopyrite, sphalerite, gold [3].
Ore composition	Diamond-drill core [1]: 7.90 ppm Au, 0.927 ppm Ag, 530 ppm As, 6.1 ppm B, 347 ppm Ba, <0.1 ppm Bi, 15 ppm Co, 115 ppm Cu, 15 ppb Hg, 1 ppm Mo, 57 ppm Ni, <2 ppm Pb, 42 ppm Rb, 5080 ppm S, 1.2 ppm Sb, 0.18 ppm Se, 269 ppm Sr, 0.050 ppm Te, 1.3 ppm Th, 1.2 ppm U, 340 ppm V, 8 ppm W, 100 ppm Zn, 55 ppm Zr; 45.8% SiO_2, 1.17% TiO_2, 13.2% Al_2O_3, 9.02% Fe_2O_3, 5.72% MgO, 13.6% CaO, 2.06% Na_2O, 2.06% K_2O, 0.17% P_2O_5, 5.00% LOI.
Enriched elements	Au, Ag, As, CO_2, S, Sb, Te, W [1,3].
GEOLOGY	
Major host rocks	Felsic or intermediate metapyroclastic rock [3].
Minor host rocks	Intermediate to mafic tuffs and/or tuffites, and phyllites [3].
Geological setting	The mineralisation is within a sequence of mafic metavolcanic and intermediate to mafic volcanogenic metasedimentary rocks of the >2000 Ma Kittilä Group of the Palaeoproterozoic Central Lapland Greenstone Belt [2].
Intrusives	Felsic porphyries [3].
METAMORPHISM	
Metamorphic grade	Greenschist facies.
STRUCTURAL SETTING	
Structural style	Brittle-ductile [3].
Closest major shear	A NW-trending shear or fault zone 2 km NE from the mineralisation [2].
Veins	Carbonate ± sulphide veins [3].
GENETIC MODEL	Clearly epigenetic, “mesothermal” mineralisation with a distinct structural control.
FIGURES	[2]: Regional geology map.

References

1. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
2. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
3. Roos, S. 1987. Lapista valitut vertailukohteet: Sukseton. In: H. Papunen (ed.) Lapin vulkaniittien tutkimusprojekti. Loppuraportti. Department of Geology, University of Turku, unpublished report. 287-290. (in Finnish)
4. Korkalo, T. 1998. Personal communication 01/11/98.

Name	***Suurikuusikko***				
GENETIC TYPE	Orogenic ‘mesothermal’.				
LOCATION					
Geological domain	Lapland	**Belt**	Kittilä		
Map sheet	2743 05	**X coordinate**	7535700	**Y coordinate**	2558600
Municipality	Kittilä				
Nearest town, access	50 k m NE from Kittilä. 3 km from a sealed road, a public gravel road adjacent to the area.				
MINING					
Exploration licence no.	4283/1, 5965/1.				
Present holder	Riddarhyttan Resources AB (1998-).				
Previous holders	Geological Survey of Finland (GTK) (1986-1998).				
Status of development	Prospect.				
Resources	0.05 Mt of 5.4 ppm Au [2]. 1.5 Mt at 5.9 ppm Au with 1 ppm cut-off grade [4]. 2.2 Mt at 6.5 ppm Au and 1 ppm cut-off grade [8].				
Total in-situ gold	270 kg Au [2]. 14.3 t Au [8].				
Best sections	28.6 m at 11.9 ppm Au, 20.4 m at 9.6 ppm Au [8]. In several metres or tens of metres(?) wide sectionsacross strike, 40-80 m apart and along 1300 m of strike, the grade ranges from 1.9 to 8.6 ppm Au [4]. 3 m at 6.5 ppm Au, 5 m at 4.2 ppm Au, 4 m at 2.7 ppm Au [2].				
Extent of mineralisation	The mineralised zone is subvertical, 1-60 m in width and at least 2 km long [2]. Indications of gold mineralisation (ppm-level values for Au) along the shear zone for nearly 9 km [4,6,8]. Extends at least 200-250 m below surface (open at depth) [8].				
Lodes	Vertical to subvertical, sheet-like geometry, open at depth and along strike, a set of parallel lodes within the mineralised shear zone [4,6].				
EXPLORATION					
Discovery	By GTK on 1986 [1,2]: Visible gold detected in an outcrop 4 km SSW of the Suurikuusikko deposit during regional exploration. This find and low-altitude airborne magnetic and electromagnetic survey directed detailed work to the shear zone, at the flank of a major fold, which also includes the Suurikuusikkoa area. The mineralisation was detected by diamond drilling.				
Exploration history	GTK (1986-1997) [1,2]: High- and low-altitude airborne magnetic, electromagnetic, gravimetric and radiometric survey, ground slingram, magnetic and VLF-R survey, regional and local till stratigraphy and geochemistry, bedrock mapping, diamond drilling. Riddarhyttan (1998-) [5,6,8]: Diamond and RC drilling, pilot plat tests, ground magnetic, IP and slingram survey.				
Drilling	GTK (1987-1990) [2]: 21 diamond-drill holes, total 2114 m. GTK 1987-1997 [4]: 77 diamond-drill holes,total 9319 m, including a 2 km long section of the shear zone drilled in profiles 40-80 m apart to the depth of 100 m. Riddarhyttan (1998-) [6,8]: a large number of diamond-drill holes and a few RC holes.				
Elements analysed	Au by GFAAS, Ag, As, Co, Cu, Mn, Ni, Pb and Zn by ICP [2]. By GFAAS: Ag, Au, Co, Cu, Mo, Ni,Pb, Te, Zn, by fire assay: Au, by ICP: Ag, Al, As, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Sc, Si, Sr, Th, Ti, V, Y, Zn [7]				
Economic evaluations	Feasibility study planned for 1999 by Riddarhyttan AB.				
Geophysical response	The graphitic, sulphide-bearing, tuffites or phyllites, i.e. the host rock types, give the major responses on both magnetic and electromagnetic methods [2].				
Primary dispersion	Au and As show a good positive correlation, while there seems not to be any correlation between Au and Sb [1].				
Exploration geologist(s) in charge	GTK: Ilkka Härkönen.				
ORE					
Siting of gold	Chiefly associated with arsenopyrite [1]. “Invisible gold” in arsenopyrite and pyrite, 93% of Au the lattice of arsenopyrite [2,6].				
Major opaques	Arsenopyrite, pyrite, graphite [1,2,7].				
Minor opaques	Pyrrhotite, gold, maldonite, native bismuth [7].				
Ore composition	Diamond-drill core [7]: 6.20 ppm Au, 1.40 ppm Ag, 4900 ppm As, 38.6 ppm B, 294 ppm Ba, <0.1 ppm Bi, 22 ppm Co, 91.4 ppm Cu, 580 ppb Hg, 2.0 ppm Mo, 153 ppm Ni, <2 ppm Pb, 26 ppm Rb, 30000 ppm S, 20.0 ppm Sb, 21.1 ppm Se, 221 ppm Sr, <0.001 ppm Te, 110 ppm Th, 1.2 ppm U, 270 ppm V, 21 ppm W, 115 ppm Zn, 62 ppm Zr; 44.5% SiO_2, 0.80% TiO_2, 7.63% Al_2O_3, 9.87% Fe_2O_3, 6.25% MgO, 9.34% CaO, 1.92% Na_2O, 1.34% K_2O, 0.26% P_2O_5, 12.1% LOI.				
Enriched elements	Ag, As, Au, Bi, CO_2, Hg, S, Sb, Se, W [2,7].				
GEOLOGY					
Major host rocks	Graphitic phyllite and/or -tuffite [1].				
Geological setting	The mineralised host rock is a large interbed between Fe- and Mg-tholeiitic metavolcanic rocks; it is part of the Porkonen Formation of the >2000 Ma Kittilä Group of the Palaeoproterozoic Central Lapland Greenstone Belt [1,2,3].				
Intrusives	Felsic “albitite” dikes, mineralised and altered, predate gold mineralisation [1,2]				

METAMORPHISM

Metamorphic grade Greenschist facies [1].

STRUCTURAL SETTING

Structural style Brittle [1].

Closest major shear A NNE-trending major shear zone 2-3 km to the west of the deposit [1].

Controlling structure The Suurikuusikko shear zone, at least 9-10 km long, N-S trending [1,4,6].

Veins Very thin (<<1 mm) graphite veins and up to 1-2 cm wide albite-carbonate ± sulphide veins brecciate the host rock [1,4,6]

ALTERATION

General alteration Albitisation, carbonation and sulphidation

TIMING The gold mineralisation in the Kuotko-Kiistala-Soretiavuoma area, which includes the Suurikuusikko mineralisation, probably took place between 1852-1890 Ma [2].

GENETIC MODEL Clearly epigenetic, "mesothermal" mineralisation with a distinct structural control [2,7,8].

FIGURES [1]: Local bedrock map.
[2]: Location of the drill holes.
[3]: Regional geology map.

References

1. Härkönen, I. & Keinänen, V. 1989. Exploration of structurally controlled gold deposits in the Central Lapland greenstone belt. Current Research 1988, Geological Survey of Finland, Special Paper 10, 79-82.
2. Härkönen, I. 1992. Tutkimustyöselostus Kittilän kunnassa valtausalueella Suurikuusikko 1, kaiv.rek. n:o 4283/1 suoritetuista malmitutkimuksista. Geological Survey of Finland, unpublished report M06/2743/-92/1/10. 5 p. (in Finnish)
3. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
4. Ministry of Industry and Trade 1997. International tender notice. Suurikuusikko gold deposit, Finland. Press release 10/11/1997.
5. Ministry of Industry and Trade 1998. Swedish Riddarhyttan Resources AB to start exploration at the Suurikuusikko gold deposit in Kittilä, northern Finland. Press release 19/04/1998.
6. Riddarhyttan Resources AB 1998. Press release 21/04/1998. (in Swedish)
7. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
8. Riddarhyttan Resources AB 1998. Press release 28/09/1998. (in Swedish)

Name	***Tuongankuusikko***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kittilä
Map sheet	3712 05 **X coordinate** 7502900 **Y coordinate** 3438900
Municipality	Kittilä
Nearest town, access	28 km E from Kittilä. One kilometre from a sealed road.
MINING	
Exploration licence no.	4570/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oy (1990-1992).
Status of development	Prospect.
Best sections	17.5 m at 1.18 ppm Au and 1.73% Cu; the best(?) 1 m sections show 1.8, 2.6, 3.0, 3.5 and 4.0 ppm Au [2].
Extent of mineralisation	Interpreted from drilling sections in the reference [2]: >300 m long, up to 10-30 m wide(?), apparently scattered, open at depth of >150 m and at both ends along strike.
Lodes	Low-grade Cu mineralisation covers most of the graphitic phyllite unit; Au mineralisation is, apparently, concentrated near the margins of the Cu mineralisation [2].
EXPLORATION	
Discovery	By Outokumpu [2]: Revision and reanalysis of exploration data from the 1960’s. The existence of gold mineralisation was confirmed by diamond drilling.
Exploration history	Outokumpu (1990-1992) [2]: till geochemical survey, magnetic and slingram ground survey, diamond drilling, trenching.
Drilling	Outokumpu (1990-1992) [2]: 12 diamond-drill holes, total 1741 m.
Elements analysed	Au, Cu [2].
Geophysical response	The graphitic phyllite gives a response on both slingram and magnetic survey [2].
Secondary dispersion	Cu and Au anomaly in till [2].
Exploration geologist(s) in charge	
	Outokumpu: Osmo Inkinen.
ORE	
Major opaques	Pyrrhotite, chalcopyrite [2]
Minor opaques	Graphite, gold [2].
Gangue	Quartz, carbonate, albite [2].
GEOLOGY	
Major host rocks	Albitised graphitic phyllite [2].
Minor host rocks	Albitised, mafic to intermediate metavolcanic rocks [2].
Geological setting	The mineralisation is in the metasedimentary rock-dominated Matarakoski Formation which belongs to the >2050 Ma Savukoski Group of the Palaeoproterozoic Central Lapland Greenstone Belt [1].
Intrusives	Fe-tholeiitic, 2.2 Ga mafic sills about 1 km SW from the mineralisation [1]. These predate peak metamorphism, peak-deformation- and gold mineralisation-related alteration.
METAMORPHISM	
Metamorphic grade	Greenschist facies [2].
STRUCTURAL SETTING	
Structural style	Brittle-ductile [2].
Closest major shear	The WNW-ESE trending Sirkka Line is adjacent to the area [1].
Controlling structure	Crossing of the Sirkka Line and a smaller NE-trending shear zone interpreted from [1].
ALTERATION	
General alteration	Pre-gold mineralisation albitisation and partial carbonation in the metavolcanic rocks? [2].
GENETIC MODEL	Clearly epigenetic, “mesothermal” mineralisation with a distinct structural control [2].
FIGURES	[1]: Regional geology map. [2]: Drilling sections with Au and Cu data for section L51.565 (drill holes TNG-15 and -22); drilling plan on electric imaginary component map.

References

1. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
2. Inkinen, O. 1992. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Kittilä, Tuongankuusikko, kaiv. rek. n:o 4570/1. Outokumpu Oy, unpublished report 080/3712/OI/92. 2 p. (in Finnish)

Name	***Apajalahti***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Belt
Map sheet	4522 09 **X coordinate** 7337900 **Y coordinate** 4444130
Municipality	Kuusamo
Nearest town, access	23 km NW from Kuusamo. Under a lake; 8 km from a sealed road; a gravel road to the lake shore, adjacent to the mineralisation.
MINING	
Present holder	OPEN FOR ACQUISITION.
Previous holders	Suomen Malmi (1957-62, 1967-69), Outokumpu Oy (1970-80), Geological Survey of Finland (GTK) (1980s).
Status of development	Prospect.
EXPLORATION	
Discovery	By Suomen Malmi
Exploration history	Suomen Malmi (1957-62, 1967-69) [2,7,9]: detailed bedrock mapping, geophysical ground surveys, till geochemistry, diamond drilling. Outokumpu (1970-80) [7,9]: detailed bedrock mapping, thin section investigations. GTK (1982-88) [1,2,3,4,5]: low-altitude airborne and ground magnetic and radiometric survey.
Elements analysed	[7]: by XRF: major elements, Cr, Sr, Ba and Zr; by AAS: Ag, Cu, Co, Pb, Ni, S, Zn.
Exploration geologist(s) in charge	Outokumpu: Jarmo Lahtinen
ORE	
Siting of gold	Native gold associated with oxides and silicates [2].
Major opaques	Pyrrhotite, pyrite [2,7,9].
Minor opaques	Chalcopyrite, ilmenite, rutile, magnetite, gold [2,7,9].
Gangue	Quartz, garnet, antophyllite, cordierite, albite, biotite, scheelite [2,7,9].
Enriched elements	Au, B, Cu, Na, S, W [2,7].
GEOLOGY	
Major host rocks	Sericite quartzite [2,7]; garnet-antophyllite "gneiss" [9].
Geological setting	The mineralisation is hosted by the rocks of the Sericite Quartzite Formation of the Kuusamo Schist Belt [2]. The schist belt is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [2,3,4,5].
METAMORPHISM	
Metamorphic grade	Upper-greenschist facies [7]. Mineral assemblages given in references 2 and 9, especially garnet-antophyllite, suggest that the peak-metamorphic grade is, at least, transitional between upper-greenschist and lower-amphibolite facies.
Metamorphic mineral assemblage	Quartzite: quartz-sericite ± biotite, microcline, tourmaline, rutile, zircon [6,7]. Quartz-sericite schist (mica schist): quartz-sericite-biotite ± epidote, albite, tourmaline, kyanite [7]. Ultramafic(?) rock: talc-quartz-chlorite-carbonate-tourmaline-rutile [7].
STRUCTURAL SETTING	
Structural style	Ductile(-brittle) [2].
Controlling structure	A NE-trending structure [2].
ALTERATION	
General alteration	The general sequence of alteration at Kuusamo is as follows [2,3,4,5,7,9]: Albitisation is the most extensivalteration type and is, apparently, premetamorphic, spilitic(?). Albitisation is followed by the syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation.
Proximal alteration	Mafic(?) host rock: garnet-antophyllite-quartz-sulphides ± magnetite, actinolite, cordierite, chlorite, calcite, albite, biotite, tourmaline, rutile [2,3,7]. Quartzite: Albite ± quartz, rutile, biotite, muscovite, pyrrhotite [3,6,7].
TIMING	Between 2050 Ma and 1800 Ma [2]. Post-peak metamorphic at 1.8-1.9 Ga [3].
GENETIC MODEL	Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [2,3,4]. Alteration and mineralisation at conditions transitional between upper-greenschist to lower-amphibolite facies [2]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [3,7,8]. Minimum temperature for Au mineralisation is

270-310°C [3].

FIGURES [2]: Regional geology map.
[7]: Local surface geology map, outcrop map and thin section photomicrographs.

References

1. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
2. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p
3. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
4. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
5. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
6. Kuronen, U. 1981. Kouvervaaran sulfidiesiintymien geologisesta ympäristöstä Kuusamon liuskealueen länsiosassa. Unpublished MSc thesis. Department of Geology, University of Turku. 102 p. (in Finnish)
7. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
8. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)
9. Roos, S. 1987. Lapista valitut vertailukohteet: Apajalahti ja Lemmonlampi. In: H. Papunen (ed.) Lapin vulkaniittien tutkimusprojekti. Loppuraportti. Department of Geology, University of Turku, unpublished report. 275-281. (In Finnish)

Name	***Hangaslampi***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Belt
Map sheet	4613 02 **X coordinate** 7354500 **Y coordinate** 4464400
Municipality	Kuusamo
Nearest town, access	36 km N from Kuusamo. 3 km from a sealed road, 500 m from a gravel road.
MINING	
Exploration licence no.	4432/2.
Mining concession no.	3965/1a.
Present holder	Outokumpu Oyj (1992-)
Previous holders	Geological Survey of Finland (GTK) (1988-91).
Status of development	Prospect.
Resources	0.28 Mt 4.8 ppm Au, with a cut off of 1 ppm; 0.25 Mt at 3.5 ppm Au, cut off: 1 ppm; all available for open cut mining [8]. About 0.4 Mt above the depth of 80 m, grade: ? [14].
Total in-situ gold	1400 kg Au [1].
Best sections	30 m at 3 ppm Au [3].
Extent of mineralisation	The larger lode: more than 200 m long (open to the south), N-S trending [3,7,8].
Lodes	Two lodes, 400 m apart [8].
EXPLORATION	
Discovery	By GTK, as a follow-up of exploration at Juomasuo, detected as a weak electric and magnetic anomaly by ground gephysical survey [8].
Exploration history	GTK (1988-91) [2,3,4,5,6,7,8,10]: detailed bedrock mapping, low-altitude airborne magnetic and radiometric survey, ground magnetic, radiometric, slingram, VLF-R and IP survey, trenching, diamond drilling, thin section investigations, till geochemical survey, ore reserve estimation. Outokumpu (1992-) [13]: diamond drilling, reserve estimation.
Drilling	GTK (1988-91) [7,8]: 43 diamond-drill holes, total 2951 m, in profiles 25 m apart. Outokumpu (1992-): diamond-drill holes in 12.5x12.5 m grid [14].
Elements analysed	[15]: Main components, Cl, Sn and Zr by XRF; Ag, As, Au, Bi, Pd, Sb, Se and Te by GFAAS; Hg by wet-chemical method; B by DCP; Ba, Cd, Co, Cr, Ga, La, Li, Mo, Nb, Ni, Pb, Rb, Sb, Sc, Sr, Th, Tl, U, V, W, Y and Zn by ICP; S by Leco.
Economic evaluations	Ore resource estimations by GTK and Outokumpu [13].
Geophysical response	Both a weak magnetic and a weak slingram ground anomaly, but only for the larger lode [3,7,8].
Primary dispersion	Not detected [13].
Secondary dispersion	Not detected [13].
Exploration geologist(s) in charge	GTK: Erkki Vanhanen.
ORE	
Siting of gold	Native gold, grain size normally 1-5 microns, between silicates [8].
Major opaques	Pyrite [3,8,10].
Minor opaques	Pyrrhotite, magnetite, molybdenite, Co-pentlandite, chalcopyrite, cobaltite, uraninite, selenides, tellurides, ilmenite, haematite, ilmenite, gold [3,6,8,10].
Ore composition	Up to 1000 ppm Co and Cu [13]. Diamond-drill core [15]: 7.90 ppm Au, 1.10 ppm Ag, 73 ppm As, 52 ppm B, 630 ppm Ba, 2.05 ppm Bi, 645 ppm Co, 97.5 ppm Cu, 6 ppb Hg, 4.9 ppm Li, <1 ppm Mo, 73 ppm Ni, 103 ppm Pb, 49 ppm Rb, 73600 ppm S, 0.22 ppm Sb, 46.70 ppm Se, <10 ppm Sr, 26.00 ppm Te, 2.6 ppm Th, 0.10 ppm Tl, 310 ppm U, 118 ppm V, 250 ppm W, 22 ppm Y, <2 ppm Zn, 55 ppm Zr; 50.4% SiO_2, 0.78% TiO_2, 14.03% Al_2O_3, 20.72% Fe_2O_3, 2.29% MgO, 0.20% CaO, 0.77% Na_2O, 3.20% K_2O, 0.03% P_2O_5.
Enriched elements	Au, Ag, As, Co, CO_2, Cu, Fe, K, Mo, Pb, S, Se, Te, U, W [13,15].
Pb isotope data	Mantle-derived lead [11]. Pb-Pb age for pyrite and pyrrhotite 1822±5 Ma [11].
GEOLOGY	
Major host rocks	Metasedimentary(?) quartz-sericite rock [3,8], metavolcanic rock [10].
Minor host rocks	Metasedimentary(?) quartz-chlorite rock [8].
Geological setting	The deposit is located in the contact zone between mafic metavolcanic rocks of the tholeiitic Greenstone Formation II and metasedimentary rocks of the Sericite Quartzite Formation of the Kuusamo Schist Belt [2,5,6]. The deposit is in the Sericite Quartzite Formation rocks [10]. The schist belt is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [3,4,5,6,10].
METAMORPHISM	
Metamorphic history	Peak regional metamorphism at lower-amphibolite facies: staurolite porphyroblasts in Al-rich rocks, formed during D1? [10]. This was followed by retrograde greenschist-facies metamorphism: sericitisation of staurolite [10], during D2?, related to NW-trending shear zones and gold mineralisation?
Metamorphic grade	Greenschist facies [4].

Metamorphic mineral assemblage	Metasedimentary rocks: quartz-albite-sericite-biotite ± chlorite [10]. Mafic(?) metavolcanic rock: albite-biotite-quartz [10].
STRUCTURAL SETTING	
Structural style	Ductile [4].
Closest major shear	A collision-related thrust fault 10 km NE of the deposit [4].
Controlling structure	WNW-trending faults which cut across the antiform [3,5], especially, areas close to the contact between Sericite Quartzite and Greenstone II Formations are critical for mineralisation [10].
Deformation history	At least two major folding stages. D1 is characterised by a major N-S trending antiform whose northern end is bended to the east due to D2; D2 is also presented by S2 foliation and a conjugate set of NW- and NE-trending, chiefly sinistral shear and fault zones [10].
Veins	Biotite-chlorite and carbonate veins [10].
ALTERATION	
General alteration	Biotitisation, chloritisation, sericitisation, silicification, carbonation [8].The general sequence of alteration at Kuusamo is as follows [3,4,5,6,9,10]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation. According to [10], carbonation and silicification post-dates all significant Au-mineralisation.
Proximal alteration	Quartz-chlorite-biotite-pyrrhotite-rutile; precursor unknown [8,10]. Quartz-sericite-chlorite-pyrite-rutile; sedimentary precursor [8,10].
Intermediate alteration	Biotite dissemination ± magnetite, pyrite, uraninite + biotite-chlorite veins [10].
Distal alteration	Carbonate dissemination + carbonate veins [10].
TIMING	Gold mineralisation during 1850-1820 Ma; U-Pb age for pyrite 1894±5 Ma and for pyrrhotite 1829±5 Ma, Pb-Pb age for pyrite and pyrrhotite 1822±5 Ma [11]. Between 2050 Ma and 1800 Ma [3]. Post-peak metamorphic at 1.8-1.9 Ga [4].
GENETIC MODEL	Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [3,4,5]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [4,9,10,12]. Minimum temperature for Au mineralisation is 270-310°C [4]. Mineralisation took place at 1820-1850 Ma indicating that the formation of late-orogenic metamorphic fluid, with Pb form mantle, was responsible for the gold mineralisation [11].
FIGURES	[3]: Regional geology map. [10]: Regional and local geology, cross section maps.

References

1. Pankka, H. 1993. Personal communication 7/9/1993.
2. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
3. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p
4. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
5. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
6. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
7. Vanhanen, E. 1991. Tutkimustyöselostus Kuusamon kunnassa valtausalueella Pohjasvaara II, kaiv.rek. n:o 4432/2 tehdyistä malmitutkimuksista. Geological Survey of Finland, unpublished report M06/4613/-91/1/10. 10 p. (in Finnish)
8. Vanhanen, E. 1992. Kuusamon Juomasuon kulta-kobolttiesiintymien lähiympäristön kultamalmitutkimukset vuosina 1986-1991. Geological Survey of Finland, unpublished report M19/4613/-92/1/10. 51 p. (in Finnish)
9. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
10. Korteniemi, J. 1993. Kultaesiintymien ympäristön hydroterminen muuttuminen Käylän alueella Kuusamossa. Unpublished MSc thesis. Department of Geology, University of Turku. 90 p. (in Finnish)
11. Mänttäri, I. 1995. Lead isotope characteristics of epigenetic gold mineralization in the Palaeoproterozoic Lapland greenstone belt, northern Finland. Geological Survey of Finland, Bulletin 381. 70 p.
12. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)
13. Vanhanen, E. 1998. Personal communication 20/8/1998.
14. Pankka, H. 1998. Personal communication 25/8/1998.
15. Bornhorst, T. & Nurmi, P. (1999) Personal communication 20/1/1999.

Name	***Hangaspuro (Juomasuo II)***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Belt
Map sheet	4613 02 **X coordinate** 7355600 **Y coordinate** 4463700
Municipality	Kuusamo
Nearest town, access	37 km N from Kuusamo. 3 km from a sealed road, a gravel road to the area.
MINING	
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	3 m at 4 ppm Au, 1 m at 9500 ppm Mo [6,7].
Extent of mineralisation	More than 150 m long, about 10 m wide, NNW-trending zone, open at both ends along strike [6,11].
EXPLORATION	
Discovery	By GTK, as a follow-up of exploration at Juomasuo: exploration in an area of a combined ground magnetic and electric anomaly [6,7,9].
Exploration history	GTK (1986-91) [1,2,3,4,5,6,7,9]: low-altitude airborne electric, magnetic and radiometric survey, ground IP, VLF-R, slingram, radiometric and magnetic survey, till geochemistry, detailed bedrock mapping, trenching, thin section investigations, diamond drilling.
Drilling	GTK: 6 diamond-drill holes, total 906 m [6,7].
Elements analysed	By GFAAS: Ag, Au, Co, Cu, Fe, Ni, Pb, Te and Zn [6].
Geophysical response	A combined ground magnetic and electric anomaly [9].
Exploration geologist(s) in charge	GTK: Erkki Vanhanen.
ORE	
Siting of gold	No native gold detected [6]. Gold is chiefly in the altered host rocks, less in the veins [11].
Major opaques	Pyrite, pyrrhotite [6,7,9].
Minor opaques	Chalcopyrite, molybdenite, uraninite, brannerite [6,7,9].
Enriched elements	Au, Co, CO_2, Cu, Mo, S, U [6].
GEOLOGY	
Major host rocks	Metasedimentary rock(s) [6,9].
Minor host rocks	Possibly, mafic metavolcanic rocks and minor dolerites [6,9].
Geological setting	The mineralisation is in the contact zones between metasedimentary and metavolcanic rocks of the Kuusamo Schist Belt[6]. The schist belt is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [2,3,4,5].
Intrusives	Differentiated, 2050 Ma dolerite(s) which predate all alteration and gold mineralisation [2,6,9].
METAMORPHISM	
Metamorphic history	Peak regional metamorphism at lower-amphibolite facies: staurolite porphyroblasts in Al-rich rocks, during D1? [9]. This was followed by retrograde greenschist-facies metamorphism: sericitisation of staurolite [9], during D2?, related to NW-trending shear zones and gold mineralisation?
Metamorphic grade	Greenschist facies [3].
Metamorphic mineral assemblage	Dolerite: albite-actinolitic hornblende-epidote-opaques ± titanite, quartz [2]. Metasedimentary rocks: quartz-albite-sericite-biotite ± chlorite [9].
STRUCTURAL SETTING	
Structural style	Brittle [11].
Closest major shear	A collision-related thrust fault 10 km NE of the deposit [3].
Controlling structure	WNW-trending faults which cut across the antiform [2,4]; contact between rock types of contrasting competence [6], especially, areas close to the contact between Sericite Quartzite and Greenstone II Formations are critical for mineralisation [9].
Deformation history	At least two major folding stages. D1 is characterised by a major N-S trending antiform whose northern end is bended to the east due to D2; D2 is also presented by S2 foliation and a conjugate set of NW- and NE-trending, chiefly sinistral shear and fault zones [9].
Veins	Quartz-carbonate ± sulphides [11].
ALTERATION	
General alteration	Carbonation + chloritisation + biotitisation + sulphidation [6]. The general sequence of alteration at Kuusamo is as follows [2,3,4,5,8,9]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au mineralisation and ductile deformation. This is followed by a stage of

	carbonation, silicification, further Au mineralisation and brittle deformation. Although, according to [9], carbonation and silicification post-dates all significant Au-mineralisation.
Proximal alteration	Metasedimentary and metavolcanic rocks: chlorite-biotite-carbonate-quartz-albite-rutile [9].
TIMING	Between 2050 Ma and 1800 Ma [2]. Post-peak metamorphic at 1.8-1.9 Ga [3].
GENETIC MODEL	Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [2,3,4]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [3,8,9,10]. Minimum temperature for Au mineralisation is 270-310°C [3].
FIGURES	[2]: Regional geology map. [9]: Regional and local geology maps.

References

1. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
2. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p.
3. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
4. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
5. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
6. Vanhanen, E. 1992. Kuusamon Juomasuon kulta-kobolttiesiintymien lähiympäristön kultamalmitutkimukset vuosina 1986-1991. Geological Survey of Finland, unpublished report M19/4613/-92/1/10. 51 p. (in Finnish)
7. Vanhanen, E. 1992. Tutkimustyöselostus Kuusamon kunnassa valtausalueella Juomasuo II, kaiv.rek. n:o 4432/1 tehdyistä malmitutkimuksista. Geological Survey of Finland, unpublished report M06/4613/-92/1/10. 10 p. (in Finnish)
8. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
9. Korteniemi, J. 1993. Kultaesiintymien ympäristön hydroterminen muuttuminen Käylän alueella Kuusamossa. Unpublished Msc thesis. Department of Geology, University of Turku. 90 p. (in Finnish)
10. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)
11. Pankka, H. 1998. Personal communication 25/8/1998.

Name *Honkilehto*

GENETIC TYPE Orogenic 'mesothermal'.

LOCATION

Geological domain	Lapland	**Belt**	Kuusamo Schist Belt		
Map sheet	4611 10	**X coordinate**	7343500	**Y coordinate**	4455000
Municipality	Kuusamo				

Nearest town, access 26 km NW from Kuusamo. 5 km from a sealed road (Highway 5), 1 km from a gravel road.

MINING

Exploration licence no. 5057/1.

Present holder Geological Survey of Finland (GTK).

Status of development Prospect.

Resources <0.01 Mt ore [8].

Total in-situ gold 20 kg [8].

EXPLORATION

Discovery GTK 1992: Au anomaly in till, trenching in the most anomalous part exposed the mineralisation in bedrock [8].

Exploration history GTK (1986-) [1,2,3,4,5]: low-altitude airborne and ground magnetic and radiometric survey, bedrock mapping, trenching, diamond drilling.

Drilling GTK (1986-) [8]: 13 diamond-drill holes, total 1437 m.

Elements analysed [9]: Main components, Cl, Sn and Zr by XRF; Ag, As, Au, Bi, Pd, Sb, Se and Te by GFAAS; Hg by wet-chemical method; B by DCP; Ba, Cd, Co, Cr, Ga, La, Li, Mo, Nb, Ni, Pb, Rb, Sb, Sc, Sr, Th, Tl, U, V, W, Y and Zn by ICP; S by Leco.

Primary dispersion Au, Co, Cu, Te [8].

Secondary dispersion Au, Co, Cu and Te anomalies in till [8].

Exploration geologist(s) in charge

GTK: Heikki Pankka.

ORE

Siting of gold Native gold and bound in sulphides [8].

Major opaques Pyrite, pyrrhotite, chalcopyrite [8].

Minor opaques Co pentlandite, native gold [8].

Ore composition Diamond-drill core [9]: 29.50 ppm Au, 1.20 ppm Ag, 19.7 ppm As, 17 ppm B, 32 ppm Ba, 0.80 ppm Bi, 1490 ppm Co, 3390 ppm Cu, <5 ppb Hg, 3.4 ppm Li, 1.0 ppm Mo, 95.9 ppm Ni, 0.4 ppm Pb, <10 ppm Rb, 76100 ppm S, 0.22 ppm Sb, 46.70 ppm Se, <10 ppm Sr, 2.20 ppm Te, 4.2 ppm Th, 0.10 ppm Tl, 3.2 ppm U, 72 ppm V, 240 ppm W, 16 ppm Y, <2 ppm Zn, 67 ppm Zr; 38.8% SiO_2, 0.26% TiO_2, 6.83% Al_2O_3, 43.27% Fe_2O_3, 2.40% MgO, 0.50% CaO, 2.80% Na_2O, 0.20% K_2O, 0.25% P_2O_5.

Enriched elements Au, Ag, As(?), Co, Cu, Fe, S, Se, Te, W [9].

GEOLOGY

Major host rocks Albitised sericite quartzite [8].

Minor host rocks Albitised metasiltstone [8].

Geological setting The mineralisation is in the Sericite Quartzite Formation(?) of the Kuusamo Schist Belt which is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [2,3,4,5].

METAMORPHISM

Metamorphic grade Greenschist facies [3].

STRUCTURAL SETTING

Controlling structure An antiform structure [4].

ALTERATION

General alteration The general sequence of alteration at Kuusamo is as follows [2,3,4,5,6]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation.

TIMING Between 2050 Ma and 1800 Ma [2]. Post-peak metamorphic at 1.8-1.9 Ga [3].

GENETIC MODEL Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [2,3,4]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [3,6,7]. Minimum temperature for Au mineralisation is 270-310°C [3].

FIGURES [2]: Regional geology map.

References

1. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
2. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p
3. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
4. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
5. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
6. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
7. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)
8. Pankka, H. 1998. Personal communication on 26/8/1998.
9. Bornhorst, T. & Nurmi, P. (1999) Personal communication 20/1/1999.

Name	***Iso-Rehvi***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Belt
Map sheet	4611 10 **X coordinate** 7347000 **Y coordinate** 4459250
Municipality	Kuusamo
Nearest town, access	28 km N from Kuusamo. 1.5 km from a sealed road (Highway 5), a gravel road to the area.
MINING	
Exploration licence no.	4442.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Resources	Approximately 0.04 Mt at 4 ppm Au [6,7].
Total in-situ gold	160 kg Au [6,7].
Best sections	7.7 m at 8.2 ppm Au, 2 m at 16 ppm Au, 1 m at 14 ppm Au [6,7].
Extent of mineralisation	200 m long, 50 m wide, 100 m deep (open at depth) [6].
EXPLORATION	
Discovery	On 1988 by the GTK: exploration targeted on a weak magnetic and electric anomaly [6].
Exploration history	GTK (1988-89) [1,2,3,4,5,6,7]: detailed bedrock mapping, low-altitude airborne and ground magnetic, electric, slingram, IP, VLF and radiometric survey, trenching, thin section investigations, diamond drilling.
Drilling	GTK (1988): 8 diamond-drill holes, total 974 m, drilled in six profiles 50 m apart [6].
Elements analysed	By AAS: Ag, Co, Cu, Mo, Ni, Pb, Zn; by GFAAS: Au, Te [6].
Geophysical response	By IP and VLF-R [10].
Exploration geologist(s) in charge	
	GTK: Erkki Vanhanen.
ORE	
Siting of gold	Free gold as inclusions and in fractures of silicates and carbonates [6,10].
Fineness	<1% Ag [6].
Major opaques	Chalcopyrite, pyrrhotite, pyrite [6].
Minor opaques	Co-pentlandite, magnetite, ilmenite, gold [6].
Gangue	Quartz, carbonate [6].
Ore composition	Average contents: 4 ppm Au, <500-1000 ppm Co, 600-1800 ppm Cu [6,7].
GEOLOGY	
Major host rocks	Metasedimentary(?) chlorite-amphibole-carbonate, chlorite-carbonate& quartz-albite-carbonate rocks [6,7].
Minor host rocks	Mafic metavolcanic rock [6].
Geological setting	Local geology comprises altered metasedimentary and metavolcanic rocks and dolerite(s); rocks of sedimentary origin dominate the area [6]. The Kuusamo Schist Belt is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [2,3,4,5].
Intrusives	2050 Ma, differentiated dolerite(s) which predate all alteration and gold mineralisation [2,6].
METAMORPHISM	
Metamorphic grade	Greenschist facies [3].
Metamorphic mineral assemblage	Dolerite: albite-actinolitic hornblende-epidote-opaques ± titanite, quartz [2].
STRUCTURAL SETTING	
Controlling structure	An antiform structure [4].
Veins	Quartz-carbonate veins [6].
ALTERATION	
General alteration	Albitisation, carbonation, chloritisation, sulphidation, silicification, weak biotitisation [6]. The general sequence of alteration at Kuusamo is as follows [2,3,4,5,8]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation.
Distal alteration	Chloritisation [6].
TIMING	Between 2050 Ma and 1800 Ma [2]. Post-peak metamorphic at 1.8-1.9 Ga [3].

GENETIC MODEL Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [2,3,4]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [3,8,9]. Minimum temperature for Au mineralisation is 270-310°C [3].

FIGURES [2]: Regional geology map.
[6,7]: Local surface geology maps.

References

1. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
2. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p
3. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
4. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
5. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
6. Vanhanen, E. 1990. Kuusamon Iso-Rehvin kultaesiintymän malmitutkimukset vuosina 1988-1989. Geological Survey of Finland, unpublished report M19/4611/90/3/10. 17 p. (in Finnish)
7. Vanhanen, E. 1991. Tutkimustyöselostus Kuusamossa valtausalueella Iso-Rehvi 1, kaiv. rek. n:o 4442, malmitutkimuksista vuosina 1988-1989. Geological Survey of Finland, unpublished report M06/4611/-91/1/10. 4 p. (in Finnish)
8. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
9. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)
10. Vanhanen, E. 1998. Personal communication 20/8/1998.

Name	***Isoaho 1***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Belt
Map sheet	4613 02 **X coordinate** 7353100 **Y coordinate** 4464900
Municipality	Kuusamo
Nearest town, access	35 km N from Kuusamo. 3 km from a sealed road, a gravel road to the area.
MINING	
Exploration licence no.	5550/1.
Present holder	Outokumpu Oyj (1992-).
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	3 m at 4 ppm Au.
EXPLORATION	
Discovery	By Outokumpu on 1975.
Exploration history	Outokumpu (1975-77) [6]: detailed bedrock mapping, diamond drilling, thin section investigations. GTK (1986-91) [1,2,3,4,5,6,8]: low-altitude airborne electric, magnetic and radiometric survey, ground IP, VLF-R, slingram, radiometric and magnetic survey, trenching, detailed bedrock mapping. Outokumpu (1992-): trenching, bedrock mapping.
Drilling	Outokumpu: 5 diamond-drill holes [6].
Geophysical response	Response on IP and radiometric methods [8].
Exploration geologist(s) in charge	Outokumpu: Osmo Inkinen; GTK: Erkki Vanhanen.
ORE	
Major opaques	Pyrrhotite, pyrite [3,6].
Enriched elements	Au, S, U [3,6].
GEOLOGY	
Major host rocks	Sericite quartzite [6].
Minor host rocks	Mafic tuffite and metalava.
Geological setting	The are is dominated by mafic metavolcanic rocks and metasedimentary rocks both sub-horizontal in their present position and cross cut by minor dolerites [6]. The deposit is in the Sericite Quartzite Formation rocks of the Kuusamo Schist Belt [8]. The schist belt is an intracratonic, failed rift filled by avolcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [2,3,4,5].
METAMORPHISM	
Metamorphic history	Peak regional metamorphism at lower-amphibolite facies: staurolite porphyroblasts in Al-rich rocks, during D1? [8]. This was followed by retrograde greenschist-facies metamorphism: sericitisation of staurolite [8], during D2?, related to NW-trending shear zones and gold mineralisation?
Metamorphic grade	Greenschist facies [3].
Metamorphic mineral assemblage	Metasedimentary rocks: quartz-albite-sericite-biotite ± chlorite, staurolite [8].
STRUCTURAL SETTING	
Structural style	Brittle-ductile.
Closest major shear	A collision-related thrust fault 10 km NE of the deposit [3].
Controlling structure	WNW-trending faults which cut across the antiform [2,4], especially, areas close to the contact between Sericite Quartzite and Greenstone II Formations are critical for mineralisation [8].
Deformation history	At least two major folding stages. D1 is characterised by a major N-S trending antiform whose northern end is bended to the east due to D2; D2 is also presented by S2 foliation and a conjugate set of NW- and NE-trending, chiefly sinistral shear and fault zones [8].
ALTERATION	
General alteration	Sericitisation, chloritisation, biotitisation, sulphidation [6]. The general sequence of alteration at Kuusamo is as follows [2,3,4,5,7,8]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation. According to [8], carbonation and silicification post-dates all significant Au-mineralisation.
TIMING	Between 2050 Ma and 1800 Ma [2]. Post-peak metamorphic at 1.8-1.9 Ga [3].

GENETIC MODEL Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [2,3,4]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [3,7,8,9]. Minimum temperature for Au mineralisation is 270-310°C [3].

FIGURES [2]: Regional geology map.
[8]: Regional geology map., site photograph.

References

1. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
2. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p.
3. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
4. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
5. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
6. Vanhanen, E. 1992. Kuusamon Juomasuon kulta-kobolttiesiintymien lähiympäristön kultamalmitutkimukset vuosina 1986-1991. Geological Survey of Finland, unpublished report M19/4613/-92/1/10. 51 p. (in Finnish)
7. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
8. Korteniemi, J. 1993. Kultaesiintymien ympäristön hydroterminen muuttuminen Käylän alueella Kuusamossa. Unpublished Msc thesis. Department of Geology, University of Turku. 90 p. (in Finnish)
9. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)

Name	***Isoaho 2***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Belt
Map sheet	4613 02 **X coordinate** 7353300 **Y coordinate** 4464400
Municipality	Kuusamo
Nearest town, access	35 km N from Kuusamo. 3 km from a sealed road, a gravel road to the area.
MINING	
Exploration licence no.	5550.
Present holder	Outokumpu Oyj (1992-).
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
EXPLORATION	
Discovery	By GTK, as a follow-up of exploration at Juomasuo, detected by an IP survey and trenching [1].
Exploration history	GTK (1986-91) [1,2,3,4,5,6,8]: low-altitude airborne electric, magnetic and radiometric survey, ground IP, VLF-R, slingram, radiometric and magnetic survey, detailed bedrock mapping, till geochemistry, trenching, detailed bedrock mapping, thin section investigations. Outokumpu (1992-): trenching, bedrock mapping.
Geophysical response	Response on IP and radiometric methods [1,8].
Exploration geologist(s) in charge	GTK: Erkki Vanhanen.
ORE	
Siting of gold	Grain size of native gold is up to 1 mm [8].
Major opaques	Pyrrhotite, pyrite [1,5].
Enriched elements	Au, S, U [1,5,8].
GEOLOGY	
Major host rocks	Sericite quartzite [1].
Minor host rocks	Mafic tuffite and metalava.
Geological setting	The are is dominated by mafic metavolcanic and intermediate metasedimentary rocks both sub-horizontal in their present position and cross cut by minor dolerites [1,2,4,5,6,8]. The deposit is in the Sericite Quartzite Formation rocks of the Kuusamo Schist Belt [8]. The schist belt is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement.
METAMORPHISM	
Metamorphic history	Peak regional metamorphism at lower-amphibolite facies: staurolite porphyroblasts in Al-rich rocks, during D1? [8]. This was followed by retrograde greenschist-facies metamorphism: sericitisation of staurolite [8], during D2?, related to NW-trending shear zones and gold mineralisation?
Metamorphic grade	Greenschist facies [5].
Metamorphic mineral assemblage	Metasedimentary rocks: quartz-albite-sericite-biotite ± chlorite, staurolite [8].
STRUCTURAL SETTING	
Structural style	Brittle-ductile.
Closest major shear	A collision-related thrust fault 10 km NE of the deposit [4].
Controlling structure	WNW-trending faults which cut across the antiform [2,4], especially, areas close to the contact between Sericite Quartzite and Greenstone II Formations are critical for mineralisation [8].
Deformation history	At least two major folding stages. D1 is characterised by a major N-S trending antiform whose northern end is bended to the east due to D2; D2 is also presented by S2 foliation and a conjugate set of NW- and NE-trending, chiefly sinistral shear and fault zones [8].
ALTERATION	
General alteration	Sericitisation, chloritisation, biotitisation, sulphidation [1]. The general sequence of alteration at Kuusamo is as follows [2,4,5,6,7,8]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation. According to [8], carbonation and silicification post-dates all significant Au-mineralisation.
Proximal alteration	Sericite quartzite, the main host rock: sericite-biotite-albite-quartz [14].
TIMING	Between 2050 Ma and 1800 Ma [4]. Post-peak metamorphic at 1.8-1.9 Ga [5].

GENETIC MODEL Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [2,4,5]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [5,7,8,9]. Minimum temperature for Au mineralisation is 270-310°C [5].

FIGURES [8]: Regional geology map, site photograph.

References

1. Vanhanen, E. 1992. Kuusamon Juomasuon kulta-kobolttiesiintymien lähiympäristön kultamalmitutkimukset vuosina 1986-1991. Geological Survey of Finland, unpublished report M19/4613/-92/1/10. 51 p. (in Finnish)
2. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
3. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
4. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p.
5. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
6. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
7. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamom area. Geological Survey of Finland, Special Paper 13, 91-97.
8. Korteniemi, J. 1993. Kultaesiintymien ympäristön hydroterminen muuttuminen Käylän alueella Kuusamossa. Unpublished Msc thesis. Department of Geology, University of Turku. 90 p. (in Finnish)
9. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)

Name	***Juomasuo***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Belt
Map sheet	4613 02 **X coordinate** 7355400 **Y coordinate** 4464230
Municipality	Kuusamo
Nearest town, access	37 km N from Kuusamo. 3 km from a sealed road, a gravel road to the area.
MINING	
Exploration licence no.	3965/1.
Mining concession no.	3965/1a.
Present holder	Outokumpu Oyj (1990-).
Previous holders	Geological Survey of Finland (GTK) (1983-90).
Status of development	Test pit
When mined	1992.
Resources	0.7 Mt at 6 ppm Au and 0.15% Co (cut off 1 ppm Au) [1]. 0.86 Mt at 5.2 ppm Au with 1 ppm cut off [3,6,9].
Total in-situ gold	4200 kg Au [1]; 4468 kg Au [9].
Best sections	24 m at 4.5 ppm Au and 0.20% Co [13].
Extent of mineralisation	100 m long, 30 m wide, at least 300 m deep mineralised zone [6,7,13]. Oval- or sheet-shaped, 50 x 100 x >300 m (depth) in size, dip approx. 50° to the SW [4]. In addition, a number of smaller Au mineralisations exist within 0.5-2 km from the main deposit [13].
Lodes	A set of Au-rich, parallel subzones within the Co mineralisation [13].
EXPLORATION	
Discovery	On 1985 by GTK: ground geophysical checking of a low-altitude airborne electric anomaly [2,13].
Exploration history	GTK (1983-89) [2,3,4,5,6,11,13]: detailed bedrock mapping, low-altitude airborne and ground magnetic, electric, slingram, gravimetry, IP, VLF-R and radiometric survey, till stratigraphy and geochemistry, diamond drilling, thin section investigations, detailed study on mineralogy and geochemistry. Outokumpu (1990-): pilot plant tests, diamond drilling.
Drilling	GTK (1985-89): 44 diamond-drill holes, total 7241 m [13]. Outokumpu (1992-): Several diamond-drill holes [1].
Elements analysed	By AAS partial leach Ag, As, Co, Cu, Fe, Mo, Ni, Pb, W, Zn, by fire assay: Au and Te, by Leco: S, by MCA: U [7,13].
Economic evaluations	Preliminary feasibility study by GTK 1989 [9]Economic evaluatuions by Outokumpu (1992-).
Geophysical response	Distinct uranium gamma-ray and electric anomalies, defined by airborne survey data, and slingram, IP and VLF ground anomalies [2,3,4].
Primary dispersion	Au, U, W, Te and Se show significant positive correlation; the Te anomaly extends beyond Au anomaly [3,4,13].
Exploration geologist(s) in charge	GTK: Heikki Pankka.
ORE	
Siting of gold	Native gold is chiefly associated with Bi and Te minerals as inclusions in pyrite, cobaltite and uraninite,between silicates, and tiny Au-Bi-Te veinlets oriented parallel with foliation and enveloped by silicates [3,4,6,11,13].
Fineness	95.8% Au, 2.5% Ag, 1.67% Se [4].
Major opaques	Pyrrhotite, pyrite [3,4,6,13].
Minor opaques	Co-pentlandite, magnetite, rutile, cobaltite, linneaite, chalcopyrite, molybdenite, uraninite, radiogenic galena, ilmenite, gold, altaite, calaverite, frohbergite, melonite, rucklidgeite, tellurobismuthite, mattagamite, kawazulite [3,4,6,7,11,13].
Gangue	Sericite, quartz, Fe dolomite, scheelite [3,4,6,13].
Ore composition	24 m long, “typical” section [7]: 3.7 ppm Au, 1.0 ppm Ag, 1980 ppm Co, 230 ppm Cu, 120 ppm Ni, 100 ppm Pb, 15 ppm Zn. “Typical ore” [6]: 6 ppm Au, 1500 ppm As, 2000 ppm Co, <500 ppm Cu, 6-7% S, 6-7 ppm Te. Diamond-drill core [8]: 4.10 ppm Au, 0.16 ppm Ag, 1200 ppm As, 54.6 ppm B, 298 ppm Ba, 2.7 ppm Bi, 1820 ppm Co, 226 ppm Cu, 5 ppb Hg, 13 ppm Mo, 122 ppm Ni, 85 ppm Pb, 84 ppm Rb, 58700 ppm S, 0.4 ppm Sb, 78 ppm Se, 10 ppm Sr, 7.00 ppm Te, 8.1 ppm Th, 284 ppm U, 130 ppm V, 390 ppm W, 45.7 ppm Zn; 57.5% SiO_2, 0.45% TiO_2, 15.0% Al_2O_3, 13.1% Fe_2O_3, 2.37% MgO, 0.04% CaO, 0.63% Na_2O, 4.41% K_2O, <0.002% P_2O_5, 5.00% LOI.
Enriched elements	Ag, As, Au, Ba, Bi, Co, K, Li, Mo, Ni, Pb, Rb, Se, Te, U, V, W [3,4,6,7,8,13].
GEOLOGY	
Major host rocks	Mafic metavolcanic rocks [4].
Minor host rocks	Sericite quartzite [3,4,6], mafic and/or ultramafic dykes [13].

Geological setting	The deposit is in the Sericite Quartzite Formation (of the Kuusamo Schist Belt) containing metasedimentary and metavolcanic rocks, and dolerites [3,4,6,11,13]. The schist belt is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [3,4,5,6,11,13].
Intrusives	Mafic and/or ultramafic dikes: altered, mineralised, conformably related to the metasedimentary rocks [13].
METAMORPHISM	
Metamorphic history	Peak regional metamorphism at lower-amphibolite facies: staurolite porphyroblasts in Al-rich rocks, during D1? [11]. This was followed by retrograde greenschist-facies metamorphism: sericitisation of staurolite [11], during D2?, related to NW-trending shear zones and gold mineralisation?
Metamorphic grade	Greenschist facies [4].
Metamorphic mineral assemblage	Metasedimentary rocks: quartz-albite-sericite-biotite ± chlorite [11].
STRUCTURAL SETTING	
Structural style	Ductile [3,5,6,13]
Closest major shear	A collision-related thrust fault 10 km NE of the deposit [4].
Controlling structure	NW-trending ductile shear zone which cut across the regional, N-S trending antiform [3,4,5,6], especially, areas close to the contact between Sericite Quartzite and Greenstone II Formations are critical for mineralisation [11].
Deformation history	At least two major folding stages. D1 is characterised by a major N-S trending antiform whose northern end is bended to the east due to D2; D2 is also presented by S2 foliation and a conjugate set of NW- and NE-trending, chiefly sinistral shear and fault zones [11].
Veins	In albitised rocks: albite and albite-quartz-carbonate veins [4].
ALTERATION	
General alteration	The general sequence of alteration at Kuusamo is as follows [3,4,5,6,10,11,13]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is retrograde(?) K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation. According to [11], carbonation and silicification post-dates all significant Au-mineralisation.
Proximal alteration	Fe-Mg silicate and K-silicate alteration: albitisation, chloritisation and sericitisation [4,13]. Mafic metavolcanic rock: sericite (phengitic muscovite)-albite-chlorite-quartz-rutile ± sulphides, biotite,magnetite [3,4,6]. Generally: sericite-chlorite-biotite ± albite, sulphides, gold [13].
Intermediate alteration	Sericite quartzite: albite-Fe dolomite-chlorite-quartz [3,4,6].
Distal alteration	Sericite quartzite: albite-quartz-sericite-rutile [4,6]. Albitisation has a lateral extent of more than 300 m; it has the widest extent of the alteration types present [4]. Mafic and/or ultramafic dikes: talc-chlorite-tremolite-actinolite-Fe dolomite-rutile ± biotite, albite, quartz, pyrite [3,4,6,13].
TIMING	Between 2050 Ma and 1800 Ma [3]. Post-peak metamorphic at 1.8-1.9 Ga [4].
GENETIC MODEL	Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [3,4,5]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [4,10,11,12]. Minimum temperature for Au mineralisation is 270-310°C [4].
FIGURES	[3]: Regional geology map, cross section, ore mineralogy photomicrographs. [4]: Regional and local geology maps, cross section, silicate and ore mineralogy photomicrographs. [11]: Regional and local geology maps, cross section. [13]: Regional geology map, cross section.

References

1. Pankka, H. 1993. Personal communication 7/9/1993.
2. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
3. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p
4. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
5. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
6. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.

7. Vanhanen, E. 1989. Uraniferous mineralizations in the Kuusamo schist belt, northeastern Finland. In: Metallogenesis of uranium deposits: proceedings of a technical committee meeting on metallogenesis of uranium deposits, Vienna 9-12 March 1987. Vienna: International Atomic Energy Agency, 169-186.
8. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
9. Parkkinen, J. 1989. Kuusamon kulta-aiheiden arviointi: Juomasuo, Sivakkaharju, Meurastuksenaho. Geological Survey of Finland, unpublished report M19/4611,4613/-89/2/10. 14 p. (in Finnish)
10. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
11. Korteniemi, J. 1993. Kultaesiintymien ympäristön hydroterminen muuttuminen Käylän alueella Kuusamossa. Unpublished MSc thesis. Department of Geology, University of Turku. 90 p. (in Finnish)
12. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)
13. Pankka, H. 1989. Kuusamon Juomasuon Co-Au esiintymän malmitutkimukset vuosina 1985-1989. Geological Survey of Finland, unpublished report M19/4613/-89/1/10. 28 p. (in Finnish)

Name	***Kantolahti***				
GENETIC TYPE	Orogenic ‘mesothermal’.				
LOCATION					
Geological domain	Lapland	**Belt**	Kuusamo Schist Belt		
Map sheet	4611 10	**X coordinate**	7349900	**Y coordinate**	4450500
Municipality	Kuusamo				
Nearest town, access	32 km NNW from Kuusamo. 0.2 km from a sealed road.				
MINING					
Exploration licence no.	3641/1.				
Present holder	OPEN FOR ACQUISITION.				
Previous holders	Geological Survey of Finland (GTK).				
Status of development	Prospect.				
Best sections	3 m at 3 ppm Au.				
Extent of mineralisation	At surface, 25 m wide; extent along strike and in depth not given [6].				
Lodes	Four parallel lodes [2].				
EXPLORATION					
Discovery	On 1983 by GTK: trenching through the overburden in a low-altitude airborne electric and magnetic anomaly [6].				
Exploration history	GTK (1986-88) [1,2,3,4,5,6]: low-altitude airborne and ground magnetic, slingram, VLF-R and radiometric survey, trenching.				
Drilling	GTK (1986-88): Five diamond-drill holes, total 568 m [9].				
Geophysical response	Airborne electric and magnetic anomaly? [6].				
Exploration geologist(s) in charge					
	GTK: Heikki Pankka.				
ORE					
Major opaques	Pyrite [2,3,6].				
Minor opaques	Rutile, pyrrhotite, chalcopyrite, Co-pentlandite, cobaltite, magnetite, ilmenite [2,3,6].				
Gangue	Quartz, albite, scheelite [6].				
Ore composition	Au up to 3 ppm, Cu 0.15%, Co 0.05-0.2% [6]				
Enriched elements	Au, Co, Cu, S, W [6].				
GEOLOGY					
Major host rocks	Mafic to intermediate tuffite [2,3,6].				
Minor host rocks	Sericite quartzite [2,6].				
Geological setting	The deposit is in the metavolcanic rock and/or in the contact zone between the metavolcanic of the tholeiitic Greenstone Formation II and metasedimentary rocks of the Sericite Quartzite Formation of the Kuusamo Schist Belt [2,5]. The schist belt is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [2,3,4,5].				
Intrusives	The 2050 Ma, differentiated dolerites cut across the metavolcanic rocks, but predate gold mineralisation (are altered) [2,6].				
METAMORPHISM					
Metamorphic grade	Greenschist facies [3].				
Metamorphic mineral assemblage	Dolerite: albite-actinolitic hornblende-epidote-opaques ± titanite, quartz [2].				
STRUCTURAL SETTING					
Structural style	Brittle-ductile [2].				
Controlling structure	Antiform structure [4].				
Veins	Calcite veins [3].				
ALTERATION					
General alteration	Albitisation, carbonation, chloritisation, sulphidation [6]. The general sequence of alteration at Kuusamo is as follows [2,3,4,5,7]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation.				
Proximal alteration	Chlorite-quartz-sericite + carbonate veins [3].				
TIMING	Between 2050 Ma and 1800 Ma [2]. Post-peak metamorphic at 1.8-1.9 Ga [3].				
GENETIC MODEL	Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [2,3,4]. The auriferous fluids were transported along deep, rift-tectonic				

faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [3,7,8]. Minimum temperature for Au mineralisation is 270-310°C [3].

FIGURES [2]: Regional geology map.

References

1. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
2. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p
3. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
4. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
5. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
6. Pankka, H. & Vanhanen, E. 1984. Kuusamon liuskealueen kulta-kobolttitutkimuksista. Summary: Cobalt-gold prospecting of the Kuusamo Schist Belt, northeastern Finland. Geologi 36, 125-130.
7. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
8. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)
9. Pankka, H. 1998. Personal communication 25/8/1998.

Name	***Konttiaho***				
GENETIC TYPE	Orogenic 'mesothermal'.				
LOCATION					
Geological domain	Lapland	**Belt**	Kuusamo Schist Belt		
Map sheet	4611 10	**X coordinate**	7343500	**Y coordinate**	4457800
Municipality	Kuusamo				
Nearest town, access	25 km N from Kuusamo. 4 km from a sealed road (Highway 5), 1 km from a gravel road.				
MINING					
Exploration licence no.	4013/2, 5092/1.				
Present holder	Outokumpu Oyj (1991-).				
Previous holders	Geological Survey of Finland (GTK).				
Status of development	Prospect.				
Resources	A few thousands of tonnes ore in the largest lode, however, drilled only to the depth of a few tens on metres [8,9].				
Best sections	8 m at 10 ppm Au [8].				
Extent of mineralisation	The mineralised pipes are in an area of 0.5 km^2 [3,5,6].				
Lodes	Two subvertical(?) pipes with a diameter of 10-20 m (major lodes) and two carbonate-vein related, minor lodes [3,5,6,8,9].				
EXPLORATION					
Discovery	Discovered on 1985 by radiometric ground survey by the GTK in an area of airborne magnetic anomaly; first indirect indications (1983) were an aeromagnetic anomaly and the occurrence of albite-rich rocks in the area [1,2,6,8,9].				
Exploration history	GTK (1985-90) [1,2,3,4,5,6,8,9]: detailed bedrock mapping, till geochemistry and stratigraphy, low-altitude airborne and ground magnetic, electric, slingram, gravimetric, IP, VLF-R and radiometric survey, trenching, diamond drilling, thin section investigations. Outokumpu (1991-) [12]: till geochemical survey.				
Drilling	GTK (1988): 12 diamond-drill holes, total 1101 m [8,9].				
Geophysical response	Response on ground IP and radiometric methods, no direct response on airborne methods [2,8].				
Primary dispersion	U and Au show a strong positive correlation with each other [8].				
Exploration geologist(s) in charge					
	GTK: Erkki Vanhanen.				
ORE					
Siting of gold	Native gold occurs as inclusions in pyrite and uraninite associated with tellurides and with carbonate veins, grain size up to visible by naked eye, up to 3 mm [2,5,8].				
Major opaques	Pyrrhotite, pyrite [2,5,6,8].				
Minor opaques	Chalcopyrite, cobaltite, Co pentlandite, molybdenite, galena, uraninite, rutile, radiogenic galena, and Ni-Co, Bi and Pb tellurides [2,3,5,6,8,9].				
Gangue	Quartz, albite, Fe dolomite, ankerite, tourmaline, scheelite [2, 6,8,9].				
Ore composition	Diamond-drill core [7]: 11.40 ppm Au, 0.103 ppm Ag, 7.5 ppm As, 141 ppm B, 85 ppm Ba, 9.4 ppm Bi, 174 ppm Co, 132 ppm Cu, 12 ppb Hg, 510 ppm Mo, 63 ppm Ni, 25 ppm Pb, 56 ppm Rb, 14300 ppm S, 0.3 ppm Sb, 39 ppm Se, 37 ppm Sr, 28.00 ppm Te, 3.8 ppm Th, 99.7 ppm U, 120 ppm V, 260 ppm W, 9.0 ppm Zn; 35.7% SiO_2, 0.45% TiO_2, 6.40% Al_2O_3, 9.26% Fe_2O_3, 10.4% MgO, 13.2% CaO, 2.15% Na_2O, 1.16% K_2O, 0.094% P_2O_5, 15.00% LOI.				
Enriched elements	Au, B, Bi, Co, CO_2, Mo, S, Se, Te, U, W [7,8].				
GEOLOGY					
Major host rocks	Sericite quartzite and albitised tuffite [6,8].				
Minor host rocks	Dolerite [8].				
Geological setting	Local geology is characterised by sedimentogeneous, altered albite-carbonate rocks of the Sericite Quartzite and Siltstone Formations and dolerites of the Kuusamo Schist Belt [2,3,8]. The schist belt is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [2,3,4,5].				
Intrusives	The differentiated, 2050 Ma, carbonated dolerites which clearly predate gold mineralisation [2,8].				
METAMORPHISM					
Metamorphic grade	Greenschist facies [3].				
Metamorphic mineral assemblage	Dolerite: albite-actinolitic hornblende-epidote-opaques ± titanite, quartz [2].				
STRUCTURAL SETTING					
Structural style	Brittle [2,3,4,5,6].				
Controlling structure	A NNE-trending shear zone [3,5].				
Veins	Pre-gold albite veins, 1-10 mm wide, and abundant syn-gold Fe dolomite ± ankerite veins, 0.1-2 m wide, brecciate the host rock [2,8]. The latter veins may also contain albite, tremolite, sericite and chlorite.				

ALTERATION

General alteration Albitisation + carbonation + chloritisation predate gold mineralisation; this stage was followed by the gold-related carbonation + biotitisation + sericitisation + sulphidation [2,5,6,8]. The general sequence of alteration at Kuusamo is as follows [2,3,4,5,10]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation.

Proximal alteration Metasedimentary rock: Albite-biotite-sericite-quartz-carbonate-sulphides-rutile [6,8].

Dolerite: albite-paragonite-carbonate-rutile [8].

TIMING Between 2050 Ma and 1800 Ma [2]. Post-peak metamorphic at 1.8-1.9 Ga [3].

GENETIC MODEL Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [2,3,4]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [3,10,11]. Minimum temperature for Au mineralisation is 270-310°C [3].

FIGURES [2]: Regional geology map, outcrop photographs.

References

1. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
2. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p
3. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
4. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
5. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
6. Vanhanen, E. 1989. Uraniferous mineralizations in the Kuusamo schist belt, northeastern Finland. In: Metallogenesis of uranium deposits: proceedings of a technical committee meeting on metallogenesis of uranium deposits, Vienna 9-12 March 1987. Vienna: International Atomic Energy Agency, 169-186.
7. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
8. Vanhanen, E. 1991. Kuusamon Konttiahon ja sen lähiympäristön kultamalmitutkimukset vuosina 1985-1990. Geological Survey of Finland, unpublished report M19/4611/-91/1/10. 12 p. (in Finnish)
9. Vanhanen, E. 1991. Tutkimustyöselostus Kuusamon kunnassa, valtausalueella Konttiaho (kaiv.rek. N:o 4013/2) tehdyistä malmi-tutkimuksista vuosina 1985-1989. Geological Survey of Finland, unpublished report M06/4611/-91/2/10. 6 p. (in Finnish)
10. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
11. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)
12. Ilvonen, E. 1998. Personal communication 17/8/1998.

Name	***Kouvervaara***				
GENETIC TYPE	Orogenic 'mesothermal'.				
LOCATION					
Geological domain	Lapland	**Belt**	Kuusamo Schist Belt		
Map sheet	4522 09	**X coordinate**	7338100	**Y coordinate**	4446800
Municipality	Kuusamo				
Nearest town, access	22 km NW from Kuusamo. 6 km from a sealed road, a gravel road to the area.				
MINING					
Exploration licence no.	5528/1.				
Present holder	Geological Survey of Finland (GTK).				
Previous holders	Suomen Malmi (1957-62, 1967-69), Outokumpu Oy (1970-80).				
Status of development	Prospect.				
Resources	1.58 Mt: 0.1% Co, 0.4 ppm Au; estimated as 10x10x10 m blocks by linear kriging with a cut off grade of 0.05% Co [2,9,10,13].				
Total in-situ gold	447 kg Au, 1560 t Co [9,10].				
Best sections	25 m at 4.5 ppm Au, 36 m at 0.25% Co [6].				
Extent of mineralisation	650 m long and up to 100 m wide, 50-60° dip to the SW [2,11]. Main part: 350 m long, 10-100 m wide at surface, extends beyond 240 m in depth [9,10]. A satellite lode: 50 m long, 5-10 m wide at surface [6].				
Lodes	Four lodes or separate ore blocks for potential open-pit mining: 0.159 Mt, 0.603 Mt, 0.147 Mt and 0.645 Mt [9,10].				
EXPLORATION					
Discovery	By GTK on 1982: following a discovery of U-rich sericite quartzite boulders on 1978, ground geophysical surveys located an electric anomaly, and trenching and drilling trough the overburden within the anomaly hit the deposit in the bedrock [2,6,8,9,10,11,12,13].				
Exploration history	Suomen Malmi (1957-62, 1967-69) [7]: detailed bedrock mapping, geophysical ground surveys, till geochemistry, diamond drilling. GTK (1980-1987) [1,2,3,4,5,8,9,10,11,12,13]: Au exploration since 1982. Low-altitude airborne and ground direct current, VLF-R, gravity, magnetic and radiometric survey, trenching and percussion drilling to the bedrock surface, diamond drilling. Ore reserve estimation, preliminary pilot plant tests [9,10,11]. Outokumpu (1970-80) [7]: started as U exploration; detailed bedrock mapping, thin section investigations.				
Drilling	GTK (1982-88): 34 diamond-drill holes, total 4704 m, drilled in profiles 25-50 m apart [6,9,10,11].				
Elements analysed	[7]: by XRF: major elements, Cr, Sr, Ba and Zr; by AAS: Ag, Cu, Co, Pb, Ni, S, Zn. [9,10,12]: by AAS partial leach Ag, Co, Cu, Fe, Ni, Pb, Zn, by fire assay: Au, by Leco: S.				
Economic evaluations	Resource estimate by the GTK on 1985 [9,10].				
Geophysical response	A magnetic anomaly envelops the deposit [10].				
Primary dispersion	Co and Au do not show any correlation: the richest Co-ore does not contain any recoverable Au [9,10].				
Exploration geologist(s) in charge	GTK: Erkki Vanhanen.				
ORE					
Siting of gold	Chiefly in garnet-bearing rocks, grain size 1-500 microns, located between silicate, magnetite and Bi-mineral grains [6,9,10].				
Fineness	<5% Ag [2].				
Major opaques	Pyrrhotite, chalcopyrite, cobaltite, Co-pentlandite [2,6,9,10,11,12].				
Minor opaques	Pyrite, rutile, native gold; in garnet-rich rocks also: magnetite, ilmenite, molybdenite, uraninite, mackinawite, linneaite, Pb-Bi tellurides [2,6,9,10,11,12].				
Gangue	Calcite [2].				
Ore composition	Average contents in the mineralisation: 0.1% Co, 0.2% Cu, 0.28 ppm Au [9,10,11].				
Enriched elements	Au, As, Bi, Co, CO_2, Cu, S, Te [6,9,10,11].				
GEOLOGY					
Major host rocks	"Garnet schist" (sericite quartzite precursor) [2,6,9,10].				
Minor host rocks	Albitised sericite quartzite and sericite schist [9,10].				
Geological setting	A set of tholeiitic dolerites has intruded into the sequence [6,7,8]. Most of the metasedimentary rocks in the Kouvervaara area are sericite quartzites and sericite schists of the Sericite Quartzite Formation belonging to the Kuusamo Schist Belt [2,8]. The schist belt is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [2,3,4,5].				
Intrusives	The 2050 Ma, differentiated dolerites predate gold mineralisation [2].				
METAMORPHISM					
Metamorphic grade	Upper-greenschist facies [7] or transition between upper-greenschist to lower-amphibolite facies at 500±50°C [8].				

Metamorphic mineral assemblage	Sericite quartzite: quartz-sericite ± biotite, fuchsite, microcline, tourmaline, rutile, zircon [6,7,8]. Quartz-sericite schist (mica schist): quartz-sericite-biotite ± fuchsite, epidote, albite, tourmaline, kyanite, staurolite, garnet, calcite [7,8]. Dolerite: albite-actinolitic hornblende-epidote-opaques ± titanite, biotite, calcite [8].
STRUCTURAL SETTING	
Structural style	Ductile(-brittle) [2].
Controlling structure	Two parallel, NNW-trending faults [2].
Deformation history	Two major stages of folding [7].
ALTERATION	
General alteration	Albitisation + carbonation + sulphidation [5,6,11]. Biotitisation + formation of garnet + sulphidation are related to Au mineralisation [6,9,10]. The general sequence of alteration at Kuusamo is as follows [2,3,4,13]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by the syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation.
Proximal alteration	Mg-Fe metasomatism [3]. Quartzites: albite ± quartz, calcite, rutile, biotite, muscovite, sulphides [2,3,6,7,8,9,10]. "Garnet schist": garnet-biotite-chlorite-tremolite-quartz-sulphides-rutile [2,3,6,9,10].
Distal alteration	Quartzite: albite-quartz-sericite-rutile [3,6,9,10].
TIMING	Between 2050 Ma and 1800 Ma [2]. Post-peak metamorphic at 1.8-1.9 Ga [3].
GENETIC MODEL	Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [2,3,4]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [3,13,14]. Minimum temperature for Au mineralisation is 270-310°C [3].
FIGURES	[2]: Regional geology map, cross section, ore mineralogy photomicrographs. [7]: Local surface geology map, outcrop photographs and thin section photomicrographs. [8]: Local surface geology map. [10]: Thin section photographs. [11]: Local surface geology with drill hole sites: the best local map?

References

1. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
2. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p
3. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
4. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
5. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
6. Pankka, H. & Vanhanen, E. 1984. Kuusamon liuskealueen kulta-kobolttitutkimuksista. Summary: Cobalt-gold prospecting of the Kuusamo Schist Belt, northeastern Finland. Geologi 36, 125-130.
7. Kuronen, U. 1981. Kouvervaaran sulfidiesiintymien geologisesta ympäristöstä Kuusamon liuskealueen länsiosassa. Unpublished MSc thesis. Department of Geology, University of Turku. 102 p. (in Finnish)
8. Vuokko, J. 1988. Kuusamon Kouvervaaran kallioperä ja siihen liittyvä uraaniesiintymä. Unpublished MSc thesis. Department of Geology, University of Turku. 105 p. (in Finnish)
9. Tarvainen, T. 1985. Kuusamon Kouvervaaran Co-Au-esiintymän malmiarvio. Unpublished MSc thesis. Geological Survey of Finland, unpublished report M19/4522/-85/1/10. 85 p. (in Finnish)
10. Tarvainen, T. 1986. Kuusamon Kouvervaaran Co-Au-esiintymän malmiarvio. Department of Geology, University of Helsinki. 89 p. (in Finnish)
11. Vanhanen, E. 1988. Tutkimustyöselostus Kuusamossa valtausalueella Kesäniemi 1 kaiv.rek. n:o 3338/1 suoritetuista malmitutkimuksista vuosina 1982-1985. Geological Survey of Finland Rep. M06/4522/-88/1/10. 4 p. (in Finnish)
12. Vanhanen, E. 1989. Uraniferous mineralizations in the Kuusamo schist belt, northeastern Finland. In: Metallogenesis of uranium deposits: proceedings of a technical committee meeting on metallogenesis of uranium deposits, Vienna 9-12 March 1987. Vienna: International Atomic Energy Agency, 169-186.
13. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
14. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)

Name	***Kuusamon Hanhilampi***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Belt
Map sheet	4613 02 **X coordinate** 7353200 **Y coordinate** 4463800
Municipality	Kuusamo
Nearest town, access	35 km N from Kuusamo. 3 km from a sealed road, a gravel road to the area.
MINING	
Exploration licence no.	5550/1.
Present holder	Outokumpu Oyj.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	5 m at 3 ppm Au [6].
EXPLORATION	
Discovery	By GTK, by a till geochemical survey, as a follow-up of exploration around the Juomasuo deposit [6]
Exploration history	GTK (1986-91) [1,2,3,4,5,6]: low-altitude airborne electric, magnetic and radiometric survey, ground IP, VLF-R, slingram and magnetic survey, till geochemistry, detailed bedrock mapping, trenching, diamond drilling.
Drilling	GTK: one diamond-drill hole, total 105.5 m [6].
Elements analysed	By GFAAS: Ag, Au, Co, Cu, Fe, Ni, Pb, Te and Zn [6].
Geophysical response	Good response on ground IP [9].
Secondary dispersion	Au anomaly in till [9].
Exploration geologist(s) in charge	GTK: Erkki Vanhanen.
ORE	
Major opaques	Pyrite [6].
Enriched elements	Au, S [9].
GEOLOGY	
Major host rocks	Sericite quartzite [6].
Geological setting	The area is dominated by mafic metavolcanic rocks and metasedimentary rocks of the Kuusamo Schist Belt. The supracrustal rocks in the area are sub-horizontal in their present position and cross cut by minor dolerites; the deposit is near the contact between metasedimentary and metavolcanic rocks [6]. The schist belt is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [2,3,4,5].
Intrusives	2050 Ma, differentiated dolerite(s), which cross cut the metasedimentary and metavolcanic rocks, predate all alteration and gold mineralisation [2,6].
METAMORPHISM	
Metamorphic grade	Greenschist facies [3].
Metamorphic mineral assemblage	Dolerite: albite-actinolitic hornblende-epidote-opaques ± titanite, quartz [2].
STRUCTURAL SETTING	
Closest major shear	A collision-related thrust fault 10 km NE of the deposit [3].
Controlling structure	WNW-trending faults which cut across the antiform [2,4].
Veins	1-3 m wide quartz veins [6].
ALTERATION	
General alteration	Sericitisation, chloritisation, biotitisation, sulphidation [6]. The general sequence of alteration at Kuusamo is as follows [2,3,4,5,7]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation.
TIMING	Between 2050 Ma and 1800 Ma [2]. Post-peak metamorphic at 1.8-1.9 Ga [3].
GENETIC MODEL	Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [2,3,4]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [3,7,8]. Minimum temperature for Au mineralisation is 270-310°C [3].
FIGURES	[2]: Regional geology map.
References	

1. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
2. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p
3. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
4. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
5. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
6. Vanhanen, E. 1992. Kuusamon Juomasuon kulta-kobolttiesiintymien lähiympäristön kultamalmitutkimukset vuosina 1986-1991. Geological Survey of Finland, unpublished report M19/4613/-92/1/10. 51 p. (in Finnish)
7. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
8. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)
9. Vanhanen, E. 1998. Personal communication 20/8/1998.

Name	***Lavasuo***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Belt
Map sheet	4611 12 **X coordinate** 7363540 **Y coordinate** 4452180
Municipality	Kuusamo
Nearest town, access	46 km NNW from Kuusamo. 5 km from a sealed road, 2 km from a gravel road.
MINING	
Exploration licence no.	3637/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oy (1983-86)
Status of development	Prospect.
Best sections	1 m at 2 ppm Au, 1 m at 1.6 ppm Au [7].
EXPLORATION	
Discovery	By Outokumpu on 1985: an electric airborne anomaly was selected as a target area where ground slingram and magnetic survey was done. This was followed by diamond drilling into a slingram anomaly detected, and the mineralisation was hit by drilling [7].
Exploration history	Outokumpu (1983-1985) [7]: detailed bedrock mapping, ground slingram and magnetic survey, diamond drilling.
Drilling	Outokumpu (1985-88): 4 diamond-drill holes, total 516 m [7].
Exploration geologist(s) in charge	
	Outokumpu: Osmo Inkinen, Heikki Vartiainen.
ORE	
Ore composition	1.33 ppm Au, 1900 ppm Co, 1600 ppm Cu, 84600 ppm S [?].
	2.05 ppm Au, 0.119 % Co, 0.104% Cu, 4.92 % S, 10.65% Fe [7].
Enriched elements	Au, Co, Cu, S [7].
GEOLOGY	
Geological setting	The mineralisation is in the Sericite Quartzite Formation(?) of the Kuusamo Schist Belt which is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [1,2,3,4].
METAMORPHISM	
Metamorphic grade	Lower-amphibolite facies(?) [2].
ALTERATION	
General alteration	The general sequence of alteration at Kuusamo is as follows [1,2,3,4,5]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation.
TIMING	Between 2050 Ma and 1800 Ma [1]. Post-peak metamorphic at 1.8-1.9 Ga [2].
GENETIC MODEL	Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [1,2,3]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [2,5,6]. Minimum temperature for Au mineralisation is 270-310°C [2].
FIGURES	[1]: Regional geology map.

References

1. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p.
2. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
3. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
4. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
5. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
6. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)
7. Inkinen, O. 1987. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Lavasuo, Kuusamo. Outokumpu Oy, unpublished report 080/4611 12/OI/87. 1p. (in Finnish)

Name	***Lemmonlampi***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Belt
Map sheet	4522 09 **X coordinate** 7339500 **Y coordinate** 4446300
Municipality	Kuusamo
Nearest town, access	23 km NW from Kuusamo. 7 km from a sealed road, a gravel road to the area.
MINING	
Present holder	OPEN FOR ACQUISITION.
Previous holders	Suomen Malmi (1957-62, 1967-69), Outokumpu Oy (1970-80), Geological Survey of Finland (GTK) (1982-1988).
Status of development	Prospect.
EXPLORATION	
Exploration history	Suomen Malmi (1957-62, 1967-69) [2,6,9]: detailed bedrock mapping, geophysical ground surveys, till geochemistry, diamond drilling. GTK (1982-88) [1,2,3,4,5]: bedrock mapping, low-altitude airborne and ground magnetic and radiometric survey. Outokumpu (1970-80) [6,9]: detailed bedrock mapping, thin section investigations.
Elements analysed	[6]: by XRF: major elements, Cr, Sr, Ba and Zr; by AAS: Ag, Cu, Co, Pb, Ni, S, Zn.
Exploration geologist(s) in charge	Outokumpu: Jarmo Lahtinen.
ORE	
Major opaques	Pyrite, pyrrhotite [2,6,9].
Minor opaques	Magnetite, chalcopyrite, ilmenite, rutile, Co-pentlandite, cobaltite [2,6,9].
Gangue	Quartz, albite, carbonate, garnet, antophyllite [9].
Enriched elements	Au, CO_2, Co, Na, S [2,6,9].
GEOLOGY	
Major host rocks	Dolerite, mica schist [2,6].
Minor host rocks	"Garnet-antophyllite rocks" [2,9].
Geological setting	The mineralisations are hosted by garnet-antophyllite gneiss [9], in any case, are in the rocks of the Sericite Quartzite Formation of the Kuusamo Schist Belt [2]. The schist belt is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [2,3,4,5].
Intrusives	Differentiated, 2050 Ma dolerite, altered, predates gold mineralisation [2,9].
METAMORPHISM	
Metamorphic grade	Upper-greenschist facies [6]. Mineral assemblages given in references 2 and 9, especially garnet-antophyllite, suggest that the peak-metamorphic grade is, at least, transitional between upper-greenschist and lower-amphibolite facies.
Metamorphic mineral assemblage	Quartzite: quartz-sericite ± biotite, microcline, tourmaline, rutile, zircon [5,6]. Quartz-sericite schist (mica schist): quartz-sericite-biotite ± epidote, albite, tourmaline, kyanite [6]. Pillowed mafic metalava: actinolitic hornblende-albite ± biotite, rutile, calcite [6]. Dolerite: actinolitic hornblende-albite-epidote-titanite ± quartz, calcite [6].
STRUCTURAL SETTING	
Structural style	Ductile(-brittle) [2].
Controlling structure	A NE-trending structure [2].
ALTERATION	
General alteration	The general sequence of alteration at Kuusamo is as follows [2,3,4,5,7,9]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic, spilitic(?). Albitisation is followed by the syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite and additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation.
Proximal alteration	Quartzite: albite ± quartz, rutile, biotite, muscovite, pyrrhotite [6]; chlorite-quartz + carbonate veins [3]. Dolerite: albite-carbonate-biotite-sulphides-quartz-rutile [6].
TIMING	Between 2050 Ma and 1800 Ma [2]. Post-peak metamorphic at 1.8-1.9 Ga [3].
GENETIC MODEL	Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [2,3,4]. Alteration and mineralisation at conditions transitional between upper-greenschist to lower-amphibolite facies [2]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [3,7,8]. Minimum temperature for Au mineralisation is 270-310°C [3].

FIGURES [2]: Regional geology map.
[6]: Local surface geology map, outcrop photographs, thin section photomicrographs.

References

1. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
2. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p
3. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
4. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
5. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
6. Kuronen, U. 1981. Kouvervaaran sulfidiesiintymien geologisesta ympäristöstä Kuusamon liuskealueen länsiosassa. Unpublished MSc thesis. Department of Geology, University of Turku. 102 p. (in Finnish)
7. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
8. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)
9. Roos, S. 1987. Lapista valitut vertailukohteet: Apajalahti ja Lemmonlampi. In: H. Papunen (ed.) Lapin vulkaniittien tutkimusprojekti. Loppuraportti. Department of Geology, University of Turku, unpublished report. 275-281. (In Finnish)

Name	***Likalampi***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Bel
Map sheet	4612 07 **X coordinate** 7370720 **Y coordinate** 4442080
Municipality	Kuusamo
Nearest town, access	56 km NNW from Kuusamo. 4 km from a sealed road, 1 km from a gravel road.
MINING	
Exploration licence no.	3638/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oy (1982-86).
Status of development	Prospect.
Extent of mineralisation	>1300 m long, 5-30 m wide [5].
EXPLORATION	
Discovery	By Outokumpu on 1983: ground geophysical surveys, trenching and drilling in an airborne electric anomaly [5].
Exploration history	Outokumpu (1982-85) [5]: trenching, detailed bedrock mapping, ground magnetic and slingram survey, diamond drilling.
Drilling	Outokumpu (1982-85): 2 diamond-drill holes [5].
Exploration geologist(s) in charge	
	Outokumpu: Osmo Inkinen.
ORE	
Major opaques	Pyrrhotite [5].
Minor opaques	Chalcopyrite, gold [5].
Ore composition	Average contents [5]: 0.5-1 ppm Au, 0.4-0.7% ppm Cu.
Enriched elements	Au, Cu, S [5].
GEOLOGY	
Geological setting	The mineralisation is in the Sericite Quartzite Formation(?) of the Kuusamo Schist Belt which is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [1,2,3,4].
METAMORPHISM	
Metamorphic grade	Lower-amphibolite facies(?) [2].
ALTERATION	
General alteration	The general sequence of alteration at Kuusamo is as follows [1,2,3,4,6]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation.
TIMING	Between 2050 Ma and 1800 Ma [1]. Post-peak metamorphic at 1.8-1.9 Ga [2].
GENETIC MODEL	Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [1,2,3]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [2,6,7]. Minimum temperature for Au mineralisation is 270-310°C [2].
FIGURES	[1]: Regional geology map.

References

1. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland.Geological Survey of Finland, Report of Investigation 101. 53 p.
2. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
3. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
4. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
5. Inkinen, O. 1987. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Kuusamo, Likalampi, kaiv. rek. n:o 3638/1. Outokumpu Oy, unpublished report 080/4612 07/OI/87. 2 p. (in Finnish)
6. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
7. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)

Name	***Meurastuksenaho***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Bel
Map sheet	4611 10 **X coordinate** 7345400 **Y coordinate** 4458700
Municipality	Kuusamo
Nearest town, access	25 km N from Kuusamo. 1 km from the sealed Highway 5, a gravel road to the area.
MINING	
Mining concession no.	1909/1a.
Present holder	Outokumpu Oyj.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Resources	0.15 Mt at 3 ppm Au and 0.25% Co [1]; 0.0344 Mt at 3.6 ppm Au [8]; 1 Mt at 0.6 ppm Au and 0.13% Co including 0.12 Mt at 4.4 ppm Au and 0.27% Co [13].
Total in-situ gold	450 kg Au [1]; 124 kg Au [8].
Extent of mineralisation	NE-trending, >220 m long (open to the NE and SW), 10-30 m wide, open at depth of 210 m, dips to the NW at 80-85° [3,13].
Lodes	One lode? [3,13].
EXPLORATION	
Discovery	By the GTK 1984: initial indication a weak aeromagnetic anomaly, this showed to contain an electric ground anomaly; the deposit was detected by trenching and drilling into the magnetic and electromagnetic anomaly [3,13].
Exploration history	GTK (1983-1989) [2,3,4,5,6,12,13]: low-altitude airborne and ground magnetic, electric and radiometric survey, trenching and diamond drilling, small-scale pilot plant tests, detailed mineralogical studies.
Drilling	GTK (1984-1986): 12 diamond-drill holes, total 2163 m [3,12,13].
Elements analysed	By AAS partial leach Ag, Co, Cu, Fe, Ni, Pb, W, Zn; by fire assay: Ag and Au; by Leco: S [7].
Economic evaluations	Preliminary feasibility study by GTK 1989 [8].
Geophysical response	A weak aeromagnetic anomaly which at ground also includes an electric anomaly [3].
Exploration geologist(s) in charge	GTK: Erkki Vanhanen.
ORE	
Siting of gold	Native gold, with a maximum detected grain size 0.5-1 mm, is chiefly related to the most Co-rich parts of the mineralisation [3].
Major opaques	Pyrrhotite, pyrite [3,4,13].
Minor opaques	Chalcopyrite, cobaltite, Co pentlandite, magnetite, bornite, covellite, molybdenite, ilmenite, uraninite, selenides, tellurides, gold [3,4,6].
Gangue	Quartz, sericite, biotite, carbonate, scheelite [3].
Ore composition	25 m long, “typical” section [7]: 1.0 ppm Au, 3.0 ppm Ag, 3460 ppm Co, 3820 ppm Cu, 70 ppm Ni, 15 ppm Pb, 25 ppm Zn.
Enriched elements	Ag, Au, Co, CO_2, Cu, S, Te, U, W [3,7,13].
Pb isotope data	Pb-Pb age for pyrrhotite 1819 Ma [10].
GEOLOGY	
Major host rocks	Sericite quartzite - metasiltstone [12,13].
Geological setting	The deposit is in the Sericite Quartzite Formation of the Kuusamo Schist Belt [3]. The schist belt is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [3,4,5,6].
METAMORPHISM	
Metamorphic grade	Greenschist facies [4].
STRUCTURAL SETTING	
Structural style	Brittle-ductile [3,4].
Controlling structure	Antiform structure [5].
Veins	Auriferous, Co-rich calcite veins [4].
ALTERATION	
General alteration	The general sequence of alteration at Kuusamo is as follows [3,4,5,6,9,13]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation. The extent of the alteration halo is not known [13].
Proximal alteration	Mg-Fe metasomatism: chlorite-quartz + carbonate veins [4].

Main host (metasedimentary rock = metasiltstone?): biotite - sericite - carbonate - quartz - albite - sulphides - rutile [3,4,13].

Minor hosts: biotite-chlorite-amphibole-sulphides-rutile ± tremolite, chloritoid, magnetite, garnet, epidote; carbonate-sulphides; garnet-epidote-biotite ± sulphides [3,13].

TIMING Pb-Pb age for pyrrhotite 1819 Ma [10]. Post-peak metamorphic at 1.8-1.9 Ga [3]. Between 2050 Ma and 1800 Ma [2].

GENETIC MODEL Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [3,4,5]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [4,9,11]. Minimum temperature for Au mineralisation is 270-310°C [4].

FIGURES [3]: Regional geology, cross section.
[13]: Plan map of the deposit at 50 m below surface, cross section with drill holes.

References

1. Pankka, H. 1993. Personal communication 7/9/1993.
2. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
3. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p
4. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
5. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
6. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
7. Vanhanen, E. 1989. Uraniferous mineralizations in the Kuusamo schist belt, northeastern Finland. In: Metallogenesis of uranium deposits: proceedings of a technical committee meeting on metallogenesis of uranium deposits, Vienna 9-12 March 1987. Vienna: International Atomic Energy Agency, 169-186.
8. Parkkinen, J. 1989. Kuusamon kulta-aiheiden arviointi: Juomasuo, Sivakkaharju, Meurastuksenaho. Geological Survey of Finland, unpublished report M19/4611,4613/-89/2/10. 14 p. (in Finnish)
9. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
10. Mänttäri, I. 1995. Lead isotope characteristics of epigenetic gold mineralization in the Palaeoproterozoic Lapland greenstone belt, northern Finland. Geological Survey of Finland, Bulletin 381. 70 p.
11. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)
12. Vanhanen, E. 1998. Personal communication 20/8/1998.
13. Vanhanen, E. 1989. Kuusamon Meurastuksenahon koboltti-kultaesiintymän malmitutkimukset 1984-1986. Geological Survey of Finland, unpublished report M19/4611/-89/1/10. 20 p. (in Finnish)

Name	***Murronmaa***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Belt
Map sheet	4611 10 **X coordinate** 7341000 **Y coordinate** 4454700
Municipality	Kuusamo
Nearest town, access	23 km NW from Kuusamo. 7 km from a sealed road (Highway 5), 500 m from a gravel road.
MINING	
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	2 m at 6 ppm Au [6].
EXPLORATION	
Exploration history	GTK (1988-89) [1,2,3,4,5,6]: low-altitude airborne magnetic and radiometric survey, ground IP, magnetic and VLF-R survey, bedrock mapping, diamond drilling.
Geophysical response	An IP anomaly [6].
Exploration geologist(s) in charge	GTK Erkki Vanhanen.
GEOLOGY	
Major host rocks	Albitised metasedimentary rock = conglomerate(?) [9].
Geological setting	The mineralisation is in the Sericite Quartzite Formation(?) of the Kuusamo Schist Belt which is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [2,3,4,5].
METAMORPHISM	
Metamorphic grade	Greenschist facies [3].
STRUCTURAL SETTING	
Controlling structure	An antiform structure [4].
ALTERATION	
General alteration	The general sequence of alteration at Kuusamo is as follows [2,3,4,5,7]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite and additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation.
TIMING	Between 2050 Ma and 1800 Ma [2]. Post-peak metamorphic at 1.8-1.9 Ga [3].
GENETIC MODEL	Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [2,3,4]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [3,7,8]. Minimum temperature for Au mineralisation is 270-310°C [3].
FIGURES	[2]: Regional geology map.

References

1. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
2. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p
3. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
4. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
5. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
6. Vanhanen, E. 1990. Sulfidimalmi- ja kultatutkimukset Kuusamon ja Sallan kuntien alueella vuosina 1983-1988 kohteissa Vilkaslampi, Painanteenniitty, Maitokoski, Perttuma-aapa, Juhonlampi, Pullealampi, Manalanniemi, Kotikumpu, Saarilampi, Paukuttaja, Ylimmäinen Kokalampi, Murronmaa, Kotisuo ja Riihilampi-Rovavaara. Geological Survey of Finland, unpublished report M19/4522, 4611, 4612, 4613/ -90/2/10. 2 p. (in Finnish)
7. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
8. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)
9. Pankka, H. 1998. Personal communication on 25/8/1998.

Name	***Ollinsuo***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Belt
Map sheet	4522 12 **X coordinate** 7338000 **Y coordinate** 4450500
Municipality	Kuusamo
Nearest town, access	21 km NW from Kuusamo. 7 km from a sealed road, a gravel road to the area.
MINING	
Exploration licence no.	3698.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK) (1984-89).
Status of development	Prospect.
Best sections	14 m at 3.3 ppm Au; 2.6 m at 5.0 ppm Au; 16 m at 1.7 ppm Au, 1100 ppm Co and 1200 ppm Cu [7].
Extent of mineralisation	150 m long, 5-40 m wide, open at the depth of 150 m, dip 70° to the NW [2,7].
EXPLORATION	
Discovery	By GTK on 1984: by drilling in an airborne and ground electric-magnetic anomaly [7].
Exploration history	GTK (1984-87) [1,2,3,4,5,7]: low-altitude airborne and ground magnetic, slingram and radiometric survey, detailed bedrock mapping, diamond drilling.
Drilling	GTK (1984): 11 diamond drill holes, total 1906 m, in 6 profiles 25-50 m apart [7]
Elements analysed	By AAS partial leach Ag, Co, Cu, Fe, Ni, Pb, Zn; by GFAAS and fire assay: Au; by Leco: S [6].
Exploration geologist(s) in charge	GTK: Heikki Pankka.
ORE	
Siting of gold	Native gold occurs associated with silicates [2].
Fineness	92.6% Au, 6.1% Ag, 1.5% Se [3].
Major opaques	Pyrrhotite, pyrite [2,3,7].
Minor opaques	Chalcopyrite, magnetite, Co-pentlandite, cobaltite, selenides, uraninite, gold, rucklidgeite [2,3,5,7].
Gangue	Quartz, biotite, calcite, scheelite [2,7].
Ore composition	19 m long, "typical" section [6]: 1.1 ppm Au, 1.3 ppm Ag, 1440 ppm Co, 1670 ppm Cu, 30 ppm Ni, 20 ppm Pb, 20 ppm Zn.
Enriched elements	Ag, Au, Co, CO_2, Cu, S, Te, U, W [2,6,7].
GEOLOGY	
Major host rocks	Metasedimentary sericite schist [2,7].
Geological setting	The deposit is in the Sericite Quartzite Formation of the Kuusamo Schist Belt [2]. The schist belt is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [2,3,4,5].
METAMORPHISM	
Metamorphic grade	Greenschist facies [3].
Metamorphic mineral assemblage	Sericite schist: quartz-sericite-dolomite-biotite [2].
STRUCTURAL SETTING	
Structural style	Brittle-ductile [3,7].
Controlling structure	An antiform structure [4]. NW-trending, steeply NE(?)-dipping shear zone [7].
Veins	Calcite, quartz and quartz-calcite veins [3].
ALTERATION	
General alteration	Biotitisation + sulphidation + carbonation [2]. The general sequence of alteration at Kuusamo is as follows [2,3,4,5,8]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite and additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation.
Proximal alteration	Chlorite-quartz + carbonate veins [3].
TIMING	Between 2050 Ma and 1800 Ma [2]. Post-peak metamorphic at 1.8-1.9 Ga [3].
GENETIC MODEL	Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [2,3,4]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [3,8,9]. Minimum temperature for Au mineralisation is 270-310°C [3].

FIGURES [2]: Regional geology map.

References

1. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
2. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p
3. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
4. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
5. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
6. Vanhanen, E. 1989. Uraniferous mineralizations in the Kuusamo schist belt, northeastern Finland. In: Metallogenesis of uranium deposits: proceedings of a technical committee meeting on metallogenesis of uranium deposits, Vienna 9-12 March 1987. Vienna: International Atomic Energy Agency, 169-186.
7. Pankka, H. 1989. Tutkimustyöselostus Kuusamon kunnassa valtausalueella Ollinsuo 1, kaiv.rek. n:o 3693, suoritetuista malmitutkimuksista. Geological Survey of Finland, unpublished report M06/4522/-89/1/10. 5 p. (in Finnish)
8. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
9. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/-92/1. 45 p. (in Finnish)

Name	***Pohjaslampi***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Belt
Map sheet	4613 02 **X coordinate** 7353400 **Y coordinate** 4464500
Municipality	Kuusamo
Nearest town, access	35 km N from Kuusamo. 3 km from a sealed road, a gravel road to the area.
MINING	
Exploration licence no.	5550/1.
Present holder	Outokumpu Oyj.
Previous holders	Outokumpu Oy (1975-77), Geological Survey of Finland (GTK) (1991-).
Status of development	Prospect.
Best sections	4 m at 4 ppm Au [6].
Lodes	Four Au-bearing lodes in the area: two of them are included into the description of the Pohjaslampi mineralsiation and the others described in Isoaho 1 and Isoaho 2 [6]. The two Pohjaslampi lodes: >100 m long, >80 m deep, and have a steep dip to the W [6].
EXPLORATION	
Discovery	By Outokumpu 1975.
Exploration history	Outokumpu (1975-77) [6,8]: detailed bedrock mapping, trenching, diamond drilling. GTK (1986-91) [1,2,3,4,5,6,8]: detailed bedrock mapping, low-altitude airborne electric, magnetic and radiometric survey, ground IP, VLF-R, slingram and magnetic survey, till geochemistry, trenching, detailed bedrock mapping, thin section investigations, diamond drilling.
Drilling	Outokumpu (1976-77) [6]: 11 diamond-drill holes. GTK [6]: 2 diamond-drill holes, total 243 m.
Elements analysed	By GFAAS: Ag, Au, Co, Cu, Fe, Ni, Pb, Te and Zn [6].
Geophysical response	A radiometric ground anomaly [8].
Exploration geologist(s) in charge	Outokumpu: Osmo Inkinen; GTK: Erkki Vanhanen.
ORE	
Major opaques	Pyrite, pyrrhotite [8].
Minor opaques	Chalcopyrite, uraninite [8].
Gangue	Quartz, carbonate, sericite, epidote [8].
Ore composition	5.8 ppm Au, 2600 ppm Cu, 860 ppm U [6].
Enriched elements	Au, CO_2, Cu, S, U [6,8].
GEOLOGY	
Major host rocks	Intermediate volcanogenic metasedimentary rock [8].
Minor host rocks	Dolerite [2,6,8].
Geological setting	The area is dominated by mafic metavolcanic rocks of the Greenstone Formation II and metasedimentary rocks of the Sericite Quartzite Formation of the Kuusamo Schist Belt, both formations being sub-horizontal in their present position and cross cut by minor dolerites [2,6,8]. The deposit is in the Sericite Quartzite Formation rocks [8]. The schist belt is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [2,3,4,5].
Intrusives	Differentiated, 2050 Ma, dolerite(s), which cut across the metasedimentary and metavolcanic rocks, but predate alteration and gold mineralisation [2,6].
METAMORPHISM	
Metamorphic history	Peak regional metamorphism at lower-amphibolite facies: staurolite porphyroblasts in Al-rich rocks, during D1? [8]. This was followed by retrograde greenschist-facies metamorphism: sericitisation of staurolite [8], during D2?, related to NW-trending shear zones and gold mineralisation?
Metamorphic grade	Greenschist facies [3].
Metamorphic mineral assemblage	Dolerite: albite-actinolitic hornblende-epidote-opaques ± titanite, quartz [2]. Volcanogenic metasedimentary rock: quartz-albite-sericite-biotite ± chlorite [8].
STRUCTURAL SETTING	
Closest major shear	A collision-related thrust fault 10 km NE of the deposit [3].
Controlling structure	NW-trending faults which cut across the antiform [2,4]. Especially, areas close to the contact between Sericite Quartzite and Greenstone II Formations are critical for mineralisation [8].
Deformation history	At least two major folding stages. D1 is characterised by a major N-S trending antiform whose northern end is bended to the east due to D2; D2 is also presented by S2 foliation and a conjugate set of NW- and NE-trending, chiefly sinistral shear and fault zones [8].

ALTERATION

General alteration Sericitisation, chloritisation, biotitisation, sulphidation [6].The general sequence of alteration at Kuusamo is as follows [2,3,4,5,7,8]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation. According to [8], carbonation and silicification post-dates all significant Au-mineralisation.

Proximal alteration Dolerite: quartz-biotite-carbonate-albite [8].

Volcanogenic metasedimentary rock: carbonate-quartz-albite(?)-sericite-biotite ± epidote, chlorite, sulphides [8].

TIMING Between 2050 Ma and 1800 Ma [2]. Post-peak metamorphic at 1.8-1.9 Ga [3].

GENETIC MODEL Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [2,3,4]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [3,7,8,9]. Minimum temperature for Au mineralisation is 270-310°C [3].

FIGURES [2]: Regional geology map.
[8]: Regional geology map, site photograph.

References

1. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
2. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p
3. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
4. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
5. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
6. Vanhanen, E. 1992. Kuusamon Juomasuon kulta-kobolttiesiintymien lähiympäristön kultamalmitutkimukset vuosina 1986-1991. Geological Survey of Finland, unpublished report M19/4613/-92/1/10. 51 p. (in Finnish)
7. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
8. Korteniemi, J. 1993. Kultaesiintymien ympäristön hydroterminen muuttuminen Käylän alueella Kuusamossa. Unpublished Msc thesis. Department of Geology, University of Turku. 90 p. (in Finnish)
9. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)

Name	***Pohjasvaara***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Belt
Map sheet	4613 02 **X coordinate** 7354200 **Y coordinate** 4465000
Municipality	Kuusamo
Nearest town, access	36 km N from Kuusamo. 4 km from a sealed road, a gravel road to the area.
MINING	
Mining concession no.	3965/2a.
Present holder	Outokumpu Oyj.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Resources	0.06 Mt 5.5 ppm Au [1].
Total in-situ gold	300 kg Au [1].
Best sections	11 m at 6.5 ppm Au [9]
Extent of mineralisation	60 m wide zone [3].
Lodes	Two lodes 10-50 m apart: the eastern is 175 m long and 10-60 m wide, and the western 100 m long and 10-40 m wide [9].
EXPLORATION	
Discovery	By the GTK on 1985.
Exploration history	GTK (1985-1992) [2,3,4,5,6,9,11]: detailed bedrock mapping, low-altitude airborne and ground magnetic, electric, slingram, gravimetry, VLF-R, IP and radiometric survey, till stratigraphy and geochemistry, diamond drilling, thin section investigations.
Drilling	GTK (1985, 1992): 19 diamond-drill holes, total 2022 m [11].
Elements analysed	By AAS partial leach Ag, Co, Cu, Fe, Ni, Pb, Zn; by fire assay: Au; by Leco: S [7]. [12]: Main components, Cl, Sn and Zr by XRF; Ag, As, Au, Bi, Pd, Sb, Se and Te by GFAAS; Hg by wet-chemical method; B by DCP; Ba, Cd, Co, Cr, Ga, La, Li, Mo, Nb, Ni, Pb, Rb, Sb, Sc, Sr, Th, Tl, U, V, W, Y and Zn by ICP; S by Leco.
Geophysical response	Response on magnetic methods, slingram, VLF and VLF-R [3].
Primary dispersion	Au, Co and Te anomalies envelop the deposit [11].
Secondary dispersion	Au, Co, Mo and Te anomaly in till [11].
Exploration geologist(s) in charge	GTK: Heikki Pankka.
ORE	
Siting of gold	Free native gold, and native gold as inclusions in sulphides [11].
Major opaques	Pyrrhotite, chalcopyrite, pyrite [3].
Minor opaques	Co-pentlandite, cobaltite, molybdenite, uraninite, selenides, tellurides, gold [3,6].
Gangue	Quartz, carbonate, sericite, epidote [8].
Ore composition	11 m long, "typical" section [7]: 5.1 ppm Au, 1.6 ppm Ag, 880 ppm Co, 1960 ppm Cu, 80 ppm Ni, 15 ppm Pb, 30 ppm Zn. Diamond-drill core [12]: 9.70 ppm Au, 1.20 ppm Ag, 1.2 ppm As, 51 ppm B, 554 ppm Ba, 1.23 ppm Bi, 1240 ppm Co, 3150 ppm Cu, 54 ppb Hg, 6.9 ppm Li, 11.8 ppm Mo, 101 ppm Ni, 3 ppm Pb, 84 ppm Rb, 74800 ppm S, 0.14 ppm Sb, 11.50 ppm Se, <10 ppm Sr, 0.78 ppm Te, 2.2 ppm Th, 0.30 ppm Tl, 2.7 ppm U, 155 ppm V, <1 ppm W, 35 ppm Y, 8.8 ppm Zn, 62 ppm Zr; 48.9% SiO_2, 0.96% TiO_2, 13.74% Al_2O_3, 20.85% Fe_2O_3, 0.26% MgO, 0.10% CaO, 0.26% Na_2O, 3.60% K_2O, 0.02% P_2O_5.
Enriched elements	Ag, Au, B, Co, Cu, Fe, Hg, K, Mo, S, Se, Te, U [3,6,7,12].
GEOLOGY	
Major host rocks	Sericite schist [3]. Mafic metavolcanic rock [4].
Geological setting	The deposit is in the sub-horizontal Sericite Quartzite Formation rocks of the Kuusamo Schist Belt, close to the contact to the Greenstone Formation II [9]. The schist belt is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [3,4,5,6,9].
METAMORPHISM	
Metamorphic history	Peak regional metamorphism at lower-amphibolite facies: staurolite porphyroblasts in Al-rich rocks, during D1? [9]. This was followed by retrograde greenschist-facies metamorphism: sericitisation of staurolite [9], during D2?, related to NW-trending shear zones and gold mineralisation?
Metamorphic grade	Greenschist facies [4].
Metamorphic mineral assemblage	Metasedimentary rocks: quartz-albite-sericite-biotite ± chlorite [9].

STRUCTURAL SETTING

Structural style	Ductile [4].
Closest major shear	A collision-related thrust fault 10 km NE of the deposit [4].
Controlling structure	WNW-trending faults which cut across the antiform [3,5]. Especially, areas close to the contact between Sericite Quartzite and Greenstone II Formations are critical for mineralisation [9].
Deformation history	At least two major folding stages. D1 is characterised by a major N-S trending antiform whose northern end is bended to the east due to D2; D2 is also presented by S2 foliation and a conjugate set of NW- and NE-trending, chiefly sinistral shear and fault zones [9].

ALTERATION

General alteration	The general sequence of alteration at Kuusamo is as follows [3,4,5,6,8,9]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation; this stage was peaked by sericitisation. This is further followed by a stage of carbonation, silicification, Au mineralisation and brittle deformation. However, according to [9], carbonation and silicification post-dates all significant Au-mineralisation.
Proximal alteration	Mafic metavolcanic rock: Sericite-chlorite-quartz-rutile ± biotite, epidote-allanite, tourmaline, amphibole, magnetite [3,4,9]. Sericitisation and chloritisation [9].
Distal alteration	Biotitisation, amphibolisation and chloritisation [9].
TIMING	Between 2050 Ma and 1800 Ma [3]. Post-peak metamorphic at 1.8-1.9 Ga [4].
GENETIC MODEL	Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [3,4,5]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [4,8,9,10]. Minimum temperature for Au mineralisation is 270-310°C [4].
FIGURES	[3]: Regional geology map.]9]: Regional and local geology maps.

References

1. Pankka, H. 1993. Personal communication 7/9/1993.
2. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
3. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p
4. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
5. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
6. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
7. Vanhanen, E. 1989. Uraniferous mineralizations in the Kuusamo schist belt, northeastern Finland. In: Metallogenesis of uranium deposits: proceedings of a technical committee meeting on metallogenesis of uranium deposits, Vienna 9-12 March 1987. Vienna: International Atomic Energy Agency, 169-186.
8. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
9. Korteniemi, J. 1993. Kultaesiintymien ympäristön hydroterminen muuttuminen Käylän alueella Kuusamossa. Unpublished Msc thesis. Department of Geology, University of Turku. 90 p. (in Finnish)
10. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)
11. Pankka, H. 1998. Personal communication 25/8/1998.
12. Bornhorst, T. & Nurmi, P. (1999) Personal communication 20/1/1999.

Name	***Sakarinkaivulamminsuo (Juomasuo II)***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Belt
Map sheet	4613 02 **X coordinate** 7355800 **Y coordinate** 4464500
Municipality	Kuusamo
Nearest town, access	37 km N from Kuusamo. 3 km from a sealed road, a gravel road to the area.
MINING	
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	2 m at 5 ppm Au; 9 m at 1300 ppm Co; 5.5 m at 4500 ppm Cu [6,7].
Extent of mineralisation	The lodes are in a E-W trending area 1 km long and 200-500 m wide [6].
Lodes	Four lodes [6]. Two main lodes, the eastern and the western [9].
EXPLORATION	
Discovery	By GTK, as a follow-up of exploration at Juomasuo: exploration in an area of a magnetic+electric anomaly [6,7].
Exploration history	GTK (1986-91) [1,2,3,4,5,6,7,9]: low-altitude airborne electric, magnetic and radiometric survey, ground radiometric, IP, VLF-R, slingram and magnetic survey, till geochemistry, detailed bedrock mapping, trenching, thin section investigations, diamond drilling.
Drilling	GTK: 8 diamond-drill holes, total 741 m [6,7].
Elements analysed	By GFAAS: Ag, Au, Co, Cu, Fe, Ni, Pb, Te and Zn [6].
Geophysical response	An IP anomaly, that has an extent of hundreds of metres, is related to the western lode, while there is no response for the eastern lode [9].
Secondary dispersion	Co, Mo and Au anomalies in till.
Exploration geologist(s) in charge	GTK: Erkki Vanhanen.
ORE	
Major opaques	Pyrrhotite, pyrite [6,7].
Minor opaques	Chalcopyrite [6,7].
Gangue	Quartz, sericite, tourmaline [8]
Enriched elements	Au, B, Co, CO_2, Cu, K, S [6,7].
GEOLOGY	
Major host rocks	Sericite quartzite [6].
Geological setting	The mineralisations are in the contact zone between the metasedimentary rocks of the Sericite Quartzite Formation and the metavolcanic rocks of the Greenstone Formation II, and in the Siltstone Formation of the Kuusamo Schist Belt [6,9]. The schist belt is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [2,3,4,5].
Intrusives	Differentiated, 2050 Ma dolerite(s), which cross cut the metasedimentary and metavolcanic rocks, predate all alteration and gold mineralisation [2,6].
METAMORPHISM	
Metamorphic history	Peak regional metamorphism at lower-amphibolite facies: staurolite porphyroblasts in Al-rich rocks, during D1? [9]. This was followed by retrograde greenschist-facies metamorphism: sericitisation of staurolite [9], during D2?, related to NW-trending shear zones and gold mineralisation?
Metamorphic grade	Greenschist facies [3].
Metamorphic mineral assemblage	Dolerite: albite-actinolitic hornblende-epidote-opaques ± titanite, quartz [2]. Metasedimentary rocks: quartz-albite-sericite-biotite ± chlorite [9].
STRUCTURAL SETTING	
Closest major shear	A collision-related thrust fault 10 km NE of the deposit [3].
Controlling structure	WNW-trending faults which cut across the antiform [2,4]. Especially, areas close to the contact between Sericite Quartzite and Greenstone II Formations are critical for mineralisation [9].
Deformation history	At least two major folding stages. D1 is characterised by a major N-S trending antiform whose northern end is bended to the east due to D2; D2 is also presented by S2 foliation and a conjugate set of NW- and NE-trending, chiefly sinistral shear and fault zones [9].
Veins	Quartz-carbonate veins [6].
ALTERATION	
General alteration	The general sequence of alteration at Kuusamo is as follows [2,3,4,5,8,9]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc, uraninite and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au

	mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation. Although, according to [9], carbonation and silicification post-dates all significant Au-mineralisation.
Proximal alteration	Inner proximal: sericitisation, outer proximal: biotitisation [9].
TIMING	Between 2050 Ma and 1800 Ma [2]. Post-peak metamorphic at 1.8-1.9 Ga [3].
GENETIC MODEL	Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [2,3,4]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; thee metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [3,8,9,10]. Minimum temperature for Au mineralisation is 270-310°C [3].
FIGURES	[2,9]: Regional geology maps.

References

1. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
2. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p.
3. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
4. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
5. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
6. Vanhanen, E. 1992. Kuusamon Juomasuon kulta-kobolttiesiintymien lähiympäristön kultamalmitutkimukset vuosina 1986-1991. Geological Survey of Finland, unpublished report M19/4613/-92/1/10. 51 p. (in Finnish)
7. Vanhanen, E. 1992. Tutkimustyöselostus Kuusamon kunnassa valtausalueella Juomasuo II, kaiv.rek. n:o 4432/1 tehdyistä malmitutkimuksista. Geological Survey of Finland, unpublished report M06/4613/-92/1/10. 10 p. (in Finnish)
8. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
9. Korteniemi, J. 1993. Kultaesiintymien ympäristön hydroterminen muuttuminen Käylän alueella Kuusamossa. Unpublished Msc thesis. Department of Geology, University of Turku. 90 p. (in Finnish)
10. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)

Name	***Sarkanniemi***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Belt
Map sheet	4611 11 **X coordinate** 7352300 **Y coordinate** 4456000
Municipality	Kuusamo
Nearest town, access	35 km NNW from Kuusamo. 1 km from a sealed road (Highway 5), a gravel road to the area.
MINING	
Exploration licence no.	4532.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	Up to 10 ppm Au detected, extent unknown [6].
EXPLORATION	
Discovery	Detected by glacial erratic boulder survey by the GTK on 1988 [6].
Exploration history	GTK (1988) [1,2,3,4,5,6]: glacial erratic boulder survey, detailed bedrock mapping, trenching, low-altitude airborne magnetic, electric, IP and VLF-R survey, ground electric and magnetic survey, till geochemistry, diamond drilling.
Drilling	GTK: 4 diamond-drill holes, total 303 m [6].
Geophysical response	No geophysical response detected [6].
Exploration geologist(s) in charge	GTK: Erkki Vanhanen, Heikki Pankka.
ORE	
Major opaques	Pyrrhotite, pyrite [6].
Enriched elements	Au, S, U [6,9].
GEOLOGY	
Major host rocks	Albitised metasedimentary rocks [9].
Geological setting	Local geology consists of dolerites, mafic metavolcanic rocks and metasedimentary sericite schists of the Kuusamo Schist Belt [6]. The schist belt is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [2,3,4,5].
METAMORPHISM	
Metamorphic grade	Greenschist facies [3].
STRUCTURAL SETTING	
Controlling structure	An antiform structure with a N-S trending shear zone in the axial plane [4,6].
ALTERATION	
General alteration	The general sequence of alteration at Kuusamo is as follows [2,3,4,5,7]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation.
TIMING	Between 2050 Ma and 1800 Ma [2]. Post-peak metamorphic at 1.8-1.9 Ga [3].
GENETIC MODEL	Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [2,3,4]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [3,7,8]. Minimum temperature for Au mineralisation is 270-310°C [3].
FIGURES	[2]: Regional geology map.

References

1. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
2. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p
3. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
4. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.

5. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
6. Pankka, H. 1993. Tutkimustyöselostus Kuusamon kunnassa valtausalueella Sarkanniemi 1, kaiv.rek. n:o 4532 suoritetuista malmitutkimuksista. Geological Survey of Finland, unpublished report M06/4611/-93/1/10. 6 p. (in Finnish)
7. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
8. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)
9. Vanhanen, E. 1998. Personal communication on 20/8/1998.

Name	***Säynäjävaara***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Belt
Map sheet	4611 07 **X coordinate** 7341500 **Y coordinate** 4449400
Municipality	Kuusamo
Nearest town, access	26 km NW from Kuusamo. 13 km from a sealed road, a gravel road to the area.
MINING	
Exploration licence no.	5635/1.
Present holder	Geological Survey of Finland (GTK).
Status of development	Prospect.
Resources	0.03 Mt 4.5 at ppm Au, or 0.4 Mt at 1 ppm Au and 600 ppm Co [2].
Total in-situ gold	140 kg Au [2]
Best sections	Several 1 m sections with 3 ppm Au [6].
Extent of mineralisation	At surface: about 2-30 m x 150 m, extends 100 m below surface, dip 70° to the SE [2,6].
EXPLORATION	
Discovery	1983 by GTK: trenching through the overburden within an anomaly defined by low-altitude airborne electric and magnetic methods [6].
Exploration history	GTK (1983) [1,2,3,4,5,6]: low-altitude airborne and ground magnetic, VLF-R and radiometric survey, diamond drilling, trenching, bedrock mapping.
Drilling	GTK (1983): 8 diamond-drill holes [6].
Elements analysed	By XRF: major components; by AAS partial leach Ag, Co, Cu, Fe, Ni, Pb, Zn; by fire assay: Au; by Leco: S [7].
Geophysical response	Ground magnetic and electromagnetic response [11].
Exploration geologist(s) in charge	GTK: Heikki Pankka.
ORE	
Siting of gold	Native gold is chiefly associated with silicates, less commonly as inclusions in pyrite [2].
Fineness	95% Au, 3% Ag, 1.5% Se [3].
Major opaques	Pyrrhotite [2,6].
Minor opaques	Pyrite, Co-pentlandite, chalcopyrite, uraninite, selenides, tellurides, rutile, gold [2,3,5,6].
Gangue	Fe dolomite [2].
Ore composition	0.12% Co [6]. High-grade Au-mineralisation, 25 m long section [7]: 4.5 ppm Au, 1.0 ppm Ag, 350 ppm Co, 280 ppm Cu, 100 ppm Ni, 25 ppm Pb, 30 ppm Zn. Diamond-drill core [8]: 3.70 ppm Au, 0.142 ppm Ag, 3.7 ppm As, 3.9 ppm B, 137 ppm Ba, 0.8 ppm Bi, 267 ppm Co, 220 ppm Cu, <5 ppb Hg, 8 ppm Mo, 69 ppm Ni, 5 ppm Pb, 68 ppm Rb, 60000 ppm S, <0.2 ppm Sb, 6.4 ppm Se, 22 ppm Sr, 0.61 ppm Te, 5.7 ppm Th, 4.0 ppm U, 92 ppm V, 6 ppm W, 51.9 ppm Zn; 37.1% SiO_2, 0.45% TiO_2, 8.55% Al_2O_3, 28.7% Fe_2O_3, 8.42% MgO, 3.75% CaO, 2.20% Na_2O, 1.47% K_2O, 0.066% P_2O_5, 5.93% LOI.
Enriched elements	Au, Ag, Co, CO_2, K, S, Se, Te, W [4,7,8].
GEOLOGY	
Major host rocks	Sericite schist [2, 6]. Mafic metavolcanic rock [4].
Minor host rocks	Sericite quartzite [6].
Geological setting	The deposit is in the Sericite Quartzite Formation of the Kuusamo Schist Belt [2]. The schist belt is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [2,3,4,5].
METAMORPHISM	
Metamorphic grade	Greenschist facies [2,3].
STRUCTURAL SETTING	
Structural style	Brittle-ductile [3,6].
Controlling structure	An antiform structure [4].
Veins	Dolomite veins [3].
ALTERATION	
General alteration	Albitisation, carbonation, chloritisation [6]. The general sequence of alteration at Kuusamo is as follows [2,3,4,5,9]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite and additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation.

Proximal alteration	Mg-Fe metasomatism: chlorite-quartz + carbonate veins [3].
	Mafic metavolcanic rock(?): Fe dolomite-chlorite-quartz ± rutile, biotite, albite, talc, magnetite, sulphides [2,4].
	Quartzite: albite-quartz-rutile ± pyrite[2].
	Chlorite-biotite rock: chlorite-biotite-quartz-rutile ± chloritoid [2].
TIMING	Between 2050 Ma and 1800 Ma [2]. Post-peak metamorphic at 1.8-1.9 Ga [3].
GENETIC MODEL	Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [2,3,4]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [3,9,10]. Minimum temperature for Au mineralisation is 270-310°C [3].
FIGURES	[2]: Regional geology map.

References

1. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data. Geological Survey of Finland, Special Paper 23, 25-28.
2. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p
3. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
4. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
5. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
6. Pankka, H. & Vanhanen, E. 1984. Kuusamon liuskealueen kulta-kobolttitutkimuksista. Summary: Cobalt-gold prospecting of the Kuusamo Schist Belt, northeastern Finland. Geologi 36, 125-130.
7. Vanhanen, E. 1989. Uraniferous mineralizations in the Kuusamo schist belt, northeastern Finland. In: Metallogenesis of uranium deposits: proceedings of a technical committee meeting on metallogenesis of uranium deposits, Vienna 9-12 March 1987. Vienna: International Atomic Energy Agency, 169-186.
8. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
9. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
10. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)
11. Pankka, H. 1998. Personal communication on 25/8/1998.

Name	***Sivakkaharju***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Kuusamo Schist Belt
Map sheet	4611 10 **X coordinate** 7344600 **Y coordinate** 4457000
Municipality	Kuusamo
Nearest town, access	27 km N from Kuusamo. 5 km from a sealed road (Highway 5), 500 m from a gravel road.
MINING	
Mining concession no.	4013/1a.
Present holder	Outokumpu Oyj.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Resources	0.05 Mt at 7 ppm Au [1,3]. 0.0306 Mt at 5.2 ppm [9].
Total in-situ gold	350 kg Au [1], 282 kg Au [9].
Extent of mineralisation	More than 50 m long, 5-10 m wide, extends >65 m in depth, open along strike and in depth [7,13].
Lodes	Two subvertical, wedge-shaped (downwards narrowing) lodes [7].
EXPLORATION	
Discovery	On 1986 by GTK: a few radioactive boulders were found on 1985 by the GTK. This led to a detailed ground radiometric survey and the discovery of the deposit by trenching in the area of the radioactive anomaly [2,7,13].
Exploration history	GTK (1983-89) [2,3,4,5,6,7,13]: low-altitude airborne and ground magnetic, electric, slingram, gravimetry, VLF-R, SP and radiometric survey, till stratigraphy and geochemistry, trenching, diamond drilling, bedrock mapping. Outokumpu (1990s) [14]: Diamond drilling.
Drilling	GTK (1986-88): 16 diamond-drill holes, total 2202 m [12].
Elements analysed	AAS partial leach: Ag, As, Co, Cu, Fe, Mo, Ni, Pb, Sb, Zn; by fire assay: Au; and by Leco: S [12,13].
Economic evaluations	Preliminary feasibility study by GTK 1989 [9].
Geophysical response	Weak IP and radiometric anomalies only detected by ground survey [3,7,13,14].
Secondary dispersion	Au, Co, Cu and Mo anomaly in till [14].
Exploration geologist(s) in charge	GTK: Erkki Vanhanen.
ORE	
Siting of gold	Native gold between silicates, associated with uraninite, and, locally, as inclusions in molybdenite, with grain size of <0.01 mm [3,13].
Fineness	96.1% Au, 1.7% Ag, 1.7% Se [4].
Major opaques	Pyrite [3,7,13].
Minor opaques	Molybdenite, chalcopyrite, Co pentlandite, rutile, uraninite, selenides, tellurides, melonite, covellite, bornite, gold [3,4,7,13].
Gangue	Quartz, sericite, chlorite, biotite, tourmaline [3,13].
Ore composition	4.5 m long, “typical” section: 5.2 ppm Au, 1.6 ppm Ag, 145 ppm Co, 1067 ppm Cu, 73 ppm Ni, 220 ppm Pb, 23 ppm Zn; on the other hand, “average mineralisation” has 10 ppm Au, 400 ppm Mo, 1000 ppm U, 300 ppm Co and 1000 ppm Cu [7]. Diamond-drill core [8]: 5.50 ppm Au, 0.099 ppm Ag, 27 ppm As, 101 ppm B, 187 ppm Ba, 11.9 ppm Bi, 172 ppm Co, 783 ppm Cu, 7 ppb Hg, 8 ppm Mo, 46 ppm Ni, <2 ppm Pb, 56 ppm Rb, 36600 ppm S, 0.9 ppm Sb, 41 ppm Se, 19 ppm Sr, 11.00 ppm Te, 4.0 ppm Th, 410 ppm U, 130 ppm V, 390 ppm W, 45.7 ppm Zn; 57.5% SiO_2, 0.45% TiO_2, 15.0% Al_2O_3, 13.1% Fe_2O_3, 2.37% MgO, 0.04% CaO, 0.63% Na_2O, 4.41% K_2O, <0.002% P_2O_5, 5.00% LOI.
Enriched elements	Ag, As, Au, B, Bi, Co, Cu, Mo, Pb, S, Se, Te, U, W [3,7,8].
GEOLOGY	
Major host rocks	Sericite schist and albitised metasedimentary rocks [3,7,12,13].
Minor host rocks	Mafic metalava [13].
Geological setting	The mineralisation is in the contact zone between fine-grained metasedimentary biotite-sericite schist (altered sericite schist?) and quartz-albite-carbonate rock (altered quartzite) in the Sericite Quartzite Formation of the Kuusamo Schist Belt [2]. The schist belt is an intracratonic, failed rift filled by a volcanosedimentary sequence deposited on late Archaean (2.6-2.8 Ga) basement [3,4,5,6].
Intrusives	2050 Ma, differentiated dolerite(s) which predate all alteration and gold mineralisation [2,3,13].
METAMORPHISM	
Metamorphic grade	Greenschist facies [3,4].
Metamorphic mineral assemblage	Dolerite: albite-actinolitic hornblende-epidote-opaques ± titanite, quartz [3]. Metasiltstone: biotite-sericite-quartz ± tourmaline, allanite, haematite [13].
STRUCTURAL SETTING	
Structural style	Ductile [3,4].

Controlling structure	An antiform structure [5], local-fault controlled [7]. At crossing of two shear zones within the antiform [13].
ALTERATION	
General alteration	The general sequence of alteration at Kuusamo is as follows [3,4,5,6,10,13]: Albitisation is the most extensive alteration type and is, apparently, premetamorphic. Albitisation is followed by a sequence of syn- to late-metamorphic(?) alteration stages. First of them is the Mg-Fe metasomatism which is closely related to gold mineralisation and indicated by formation of chlorite, tremolite-actinolite, magnetite, chloritoid, talc and Fe sulphides. The next stage is K±S metasomatism indicated by biotite and sericite ± pyrite, additional(?) Au mineralisation and ductile deformation. This is followed by a stage of carbonation, silicification, further Au mineralisation and brittle deformation.
Proximal alteration	Sericite quartzite or sericite schist: quartz-sericite ± biotite, epidote-allanite, tourmaline, haematite, chlorite, rutile [3,4,7]. Quartzite: quartz-albite-carbonate ± talc, rutile [3,7].
Intermediate alteration	Chloritisation [4].
Distal alteration	Albitisation [4].
TIMING	Between 2050 Ma and 1800 Ma [2]. Post-peak metamorphic at 1.8-1.9 Ga [3].
GENETIC MODEL	Epigenetic mineralisation in rift-filling rocks. Structurally controlled hydrothermal fluid pathways were created during post-depositional tectonic event(s) of regional scale which were related to the closure of the main rift during the Svecofennian (Svecokarelian) orogeny [3,4,5]. The auriferous fluids were transported along deep, rift-tectonic faults up to the greenschist-metamorphic environment, concentrated on the antiform; the metals precipitated in structurally controlled sites close to impermeable dolerites and metavolcanic units or, rather, in the more competent sericite quartzite units between the more plastic mafic units [4,10,11]. Minimum temperature for Au mineralisation is 270-310°C [4].
FIGURES	[3]: Regional geology map. [13]: Local surface geology map, cross section.

References

1. Pankka, H. 1993. Personal communication 7/9/1993.
2. Arkimaa, H. 1997. The fingerprints of known gold occurrences in the Kuusamo schist belt as shown by airborne gamma-ray spectrometric data.Geological Survey of Finland, Special Paper 23, 25-28.
3. Pankka, H., Puustinen, K. & Vanhanen, E. 1991. Kuusamon liuskealueen kulta-koboltti-uraaniesiintymät. Summary: Au-Co-U deposits in the Kuusamo volcano-sedimentary belt, Finland. Geological Survey of Finland, Report of Investigation 101. 53 p
4. Pankka, H. 1992. Geology and mineralogy of Au-Co-U deposits in the Proterozoic Kuusamo volcanosedimentary belt, northeastern Finland. A dissertation. Geology. Michigan Technological University. 233 p.
5. Pankka, H. 1997. Epigenetic Au-Co-U deposits in an early Proterozoic continental rift of the northern Fennoscandian Shield: a new class of ore deposit? In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 277-280.
6. Pankka, H. S. & Vanhanen, E. J. 1992. Early Proterozoic Au-Co-U mineralization in the Kuusamo district, northeastern Finland. Precambrian Research 58, 387-400.
7. Vanhanen, E. 1989. Uraniferous mineralizations in the Kuusamo schist belt, northeastern Finland. In: Metallogenesis of uranium deposits: proceedings of a technical committee meeting on metallogenesis of uranium deposits, Vienna 9-12 March 1987. Vienna: International Atomic Energy Agency, 169-186.
8. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
9. Parkkinen, J. 1989. Kuusamon kulta-aiheiden arviointi: Juomasuo, Sivakkaharju, Meurastuksenaho. Geological Survey of Finland, unpublished report M19/4611,4613/-89/2/10. 14 p. (in Finnish)
10. Vanhanen, E. 1991. Cobalt-, gold- and uranium-bearing mineralizations and their relation to deep fractures in the Kuusamo area. Geological Survey of Finland, Special Paper 13, 91-97.
11. Sorjonen-Ward, P. 1992. Kultamalmien rakennegeologiaa. Geological Survey of Finland, unpublished report M10.2/- 92/1. 45 p. (in Finnish)
12. Vanhanen, E. 1998. Personal communication 20/8/1998.
13. Vanhanen, E. 1988. Kuusamon Sivakkaharjun kultaesiintymän malmitutkimukset vuosina 1985-1988. Geological Survey ofFinland, unpublished report M19/4611/-88/1/10. 21 p. (in Finnish)
14. Pankka, H. 1998. Personal communication 26/8/1998.

Name	***Kivimaa***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Peräpohja Schist Belt
Map sheet	2631 10 **X coordinate** 7347300 **Y coordinate** 2537000
Municipality	Tervola
Nearest town, access	15 km N from Tervola, 50 km SW from Rovaniemi city and 50 km NE from Kemi. 10 km from a sealed road, 15 km from Highway 4, a gravel road to the area.
MINING	
Exploration licence no.	1835/1-5.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oy (1961-?), Geological Survey of Finland (GTK) (1983-89?), private holder (1990-1992).
Status of development	Open pit and underground, mining ceased.
When mined	1969.
Resources	Pre-mining: 0.022 Mt at 1.87% Cu and 5.3 ppm Au [11].
Total production	16000 t at 1.2% Cu and 2 ppm Au [1,8].
Total in-situ gold	374 t Cu, 106 kg Au [4].
Best sections	6.2 m at 4.9 ppm Au and 2.2% Cu [9].
Extent of mineralisation	The mineralisation is 1-6 m wide, about 350 m long, has a dip of 15-40°, extends to depth for more than 60 m; open at depth [1].
Lodes	One lode [1,7].
EXPLORATION	
Discovery	By Outokumpu on 1965: Gold- and copper-rich (100 ppm Au, 3% Cu) boulder samples provided by an amateur prospector from the region during 1960; this led Outokumpu for further boulder sampling, ground geophysical surveys and drilling; mineralisation was detected by drilling into a significant IP anomaly [1,8,10,13].
Exploration history	Outokumpu (1961-1971?) [1,10,11,12,13]: survey of glacial erratic boulders, bedrock mapping, till geochemical survey, ground magnetic, slingram and IP survey, diamond drilling. GTK (1983-1991) [2,3,4,7]: survey of glacial erratic boulders, bedrock mapping, bedrock surface sampling by drilling, stratigraphy and till geochemistry survey, low-altitude airborne magnetic, electromagnetic, radiometric and gravity survey.
Drilling	Outokumpu (1961-1967): 25 diamond-drill holes, total 2434 m [1,8,10,13].
Economic evaluations	Feasibility study by Outokumpu 1967 [11].
Geophysical response	No obvious magnetic response, but a distinct IP anomaly [1].
Secondary dispersion	A restricted Au anomaly, with high Au values (up to 0.44 ppm) in till <300 m to the E from the deposit, is probably related to the deposit [2,3]. Au-till anomalies 200-400 m to the S and SE of the Kivimaa deposit are interpreted not to be related to the mined deposit [2,3,4]. A Cu anomaly in till enveloping the deposit [10,12].
Exploration geologist(s) in charge	Outokumpu: Pentti Rouhunkoski; GTK: Matti Äyräs, Seppo Rossi.
ORE	
Siting of gold	Native gold occurs as inclusions in arsenopyrite [2,3], apparently, only in the quartz veins [7].
Major opaques	Pyrite, magnetite, chalcopyrite [1,8,9].
Minor opaques	Arsenopyrite, pyrrhotite, ilmenite, rutile, bismuthinite, native bismuth, gold, galena, fahlore [1,8,8].
Gangue	Quartz, calcite, chlorite [1,8,9,10,11].
Ore composition	By AAS(?): 1.2% Cu, 2 ppm Au [1]. Diamond-drill core [6]: 4.90 ppm Au, 2.00 ppm Ag, 220 ppm As, 1.5 ppm B, 244 ppm Ba, 21.5 ppm Bi, 24 ppm Co, 18400 ppm Cu, 180 ppb Hg, <1 ppm Mo, 197 ppm Ni, <2 ppm Pb, 13 ppm Rb, 71400 ppm S, <0.2 ppm Sb, 0.96 ppm Se, 75 ppm Sr, 0.10 ppm Te, 1.1 ppm Th, 1.2 ppm U, 92 ppm V, 27 ppm W, 123 ppm Zn; 28.8% SiO_2, 0.73% TiO_2, 3.66% Al_2O_3, 26.4% Fe_2O_3, 3.50% MgO, 15.4% CaO, 0.07% Na_2O, 0.08% K_2O, 0.018% P_2O_5, 5.23% LOI.
Enriched elements	Ag, As, Au, Bi, CO_2, Cu, K, Rb, S, Te, W [6].
GEOLOGY	
Major host rocks	Dolerite sill (“albite diabase”) [1,2,7,9,10].
Minor host rocks	Mafic metavolcanic rock [2].
Geological setting	Conformable, 2.2 Ga, dolerite dikes in a sequence of mafic metavolcanic rocks in near-top area of the flank of a major fold in the central part of the Peräpohja Schist Belt [1,5,8].
Intrusives	Differentiated, Fe-tholeiitic dolerite: the host rock [1,7].
METAMORPHISM	
Metamorphic grade	Upper-greenschist facies: interpreted from [1-5] and [8-10].
Metamorphic mineral assemblage	Dolerite: albite-actinolite-chlorite-epidote-quartz-calcite [1].

STRUCTURAL SETTING

Structural style	Brittle-ductile [1].
Controlling structure	The main vein is in a dip-slip fault [1].
Ore fabric	Banded, unfoliated [1].
Veins	A large quartz-calcite-sulphide vein with distinct banding, and a set of similar, smaller veins [1,7].
ALTERATION	
General alteration	Calcite-chlorite ± biotite alteration zone, <1-5 m wide, envelops the veins [1,8]. A set of parallel, partially overlapping alteration zones [8].
Proximal alteration	Calcite-chlorite-albite-pyrite [1] or chlorite-carbonate-biotite [7]. Calcite-chlorite-biotite-albite-quartz-sulphides [8].
TIMING	Post-2.2 Ga [1,5].
GENETIC MODEL	All data in the references [1,2,3,4,5] suggest epigenetic 'mesothermal' origin. Late-magmatic suggested in [1].
FIGURES	[1]: Cross section. [5]: Aerial photograph of the area.

References

1. Rouhunkoski, P. & Isokangas, P. 1974. The copper-gold vein deposit of Kivimaa at Tervola, N-Finland. Bulletin of the Geological Society of Finland 46, 29-35.
2. Äyräs, M. 1988. Geokemiallisia kultatutkimuksia Peräpohjan liuskealueella. Annales Universitatis Turkuensis, Sarja C, Tom 67, 89-88. (in Finnish)
3. Koivisto, T. 1984. Geokemialliset tarkistustutkimukset Peräpohjan liuskealueella: Moreenigeokemialliset kultatutkimukset Kivimaan ja Vinsan tunnettujen Cu-Au-juonimuodostumien ympäristössä. Tutkimusraportti nro 1. Geological Survey of Finland, unpublished report S/41/2544/1/1984. 19 p. (in Finnish)
4. Äyräs, M. 1991. Maaperägeokemialliset tutkimukset Tervolan Kivimaalla vuosina 1990-91. Geological Survey of Finland, unpublished report S/41/2631/1/1991. 16 p. (in Finnish)
5. Rossi, S. 1993. Kultalohkareaiheen malmitutkimukset Peräpohjan liuskealueella Sivakkajoen varressa Kivimaassa Tervolan kunnan luoteisosassa vuosina 1989-1992. Geological Survey of Finland, unpublished report M19/2631/-93/1/10. 33 p. (in Finnish)
6. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
7. Rossi, S. 1998. Personal communication on 14/8/1998.
8. Lehtinen, M. & Eilu, P. 1987. Diabaaseihin liittyvät malmiaiheet: Kivimaa. In: H. Papunen (ed.) Lapin vulkaniittien tutkimusprojekti. Loppuraportti. Department of Geology, University of Turku, unpublished report. 346-352. (in Finnish)
9. Eilu, P. 1987. Diabaasikohteiden geokemiaa. In: H. Papunen (ed.) Lapin vulkaniittien tutkimusprojekti. Loppuraportti. Department of Geology, University of Turku, unpublished report. 365-385. (in Finnish)
10. Rouhunkoski, P. 1967. Tervola T/1, Kivimaa. Outokumpu Oy, unpublished report 001/2631/PR/76 11 p. (in Finnish)
11. Aulanko, H. 1968. Tervolan Kivimaan Cu-Au-esiintymän hyväksikäyttö. Outokumpu Oy, unpublished report 035/2631/HA/68-69. 7 p. (in Finnish)
12. Wennervirta, H. 1966. Moreenitutkimus, Tervola, Kivimaa. Outokumpu Oy, unpublished report 062/2631/HW/66. 1 p. (in Finnish)
13. Isokangas, P. 1968. Kaivospiirihakemus. Tervola, Kivimaa. Outokumpu Oy, unpublished report. 2 p. (in Finnish)

Name	***Petäjävaara (Rosvohotu)***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Lapland **Belt** Peräpohja Schist Belt
Map sheet	2633 08 **X coordinate** 7355000 **Y coordinate** 2563000
Municipality	Rovaniemi rural municipality
Nearest town, access	25 km SW from the city of Rovaniemi. Gravel roads to the area, 0.5 km to a sealed road, 5 km to the Highway 4.
MINING	
Exploration licence no.	4465.
Present holder	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	1 m at 19.6 ppm Au, 1 m at 3 ppm Au [3].
Extent of mineralisation	About a 20 m wide, possibly 1 km long zone; it may be part of mineralised and sheared zones in en echelon setting extending in E-W direction for >10 km [2,3].
EXPLORATION	
Discovery	By GTK on 1992: the mineralisation was detected by trenching and drilling into a till geochemical and ground geophysical anomaly [1,2].
Exploration history	GTK (1981-) [1,2]: till stratigraphy and geochemistry survey, bedrock mapping, diamond drilling, low-altitude airborne magnetic, electromagnetic, radiometric and gravity survey, ground IP, SP, VLF, slingram and magnetic survey, percussion drilling into bedrock surface through overburden, detailed mineralogical study.
Drilling	GTK (1992-1996): 10 diamond-drill holes, total 592 m [2].
Elements analysed	By ICP: As, B, Ba, Cd, Co, Cr, Cu, Fe, K, La, Li, Mg, Mo, Na, Ni, P, Pb, S, Sb, Sc, Sr, Th, Ti, V, Y, Zn and by GFAAS: Au, Pd, Te [3].
Geophysical response	A ground SP anomaly, no response on other electromagnetic or magnetic methods [2,3].
Primary dispersion	Au and Cu anomalies envelop the mineralisation [2].
Secondary dispersion	Several hundreds of metres long Au-Cu anomaly in till [1]. In till, the best indicators for the mineralisation are Au, Cu, Co and Te anomalies [2]. No correlation between Au and As in till [2].
Exploration geologist(s) in charge	GTK: Seppo Rossi.
ORE	
Major opaques	Pyrite, magnetite [1,2].
Minor opaques	Chalcopyrite, pyrrhotite [1,2].
Gangue	Quartz, carbonate, biotite [1,2,3].
Ore composition	A set of about 20 "best" grab samples: 1.9 ppm Au, 2.9 % Cu [2,3].
Enriched elements	Au, Co, CO_2, Cu, K, Rb, S, Te [2,3].
GEOLOGY	
Major host rocks	Differentiated dolerite [1,3].
Minor host rocks	Quartzite, mafic metavolcanic rock [1,3].
Geological setting	The mineralisation is in the contact zone between dolerite-volcanic rock and quartzite sequences in the Palaeoproterozoic Peräpohja Schist Belt [3].
Intrusives	Differentiated, 2.2 Ga, dolerites which predate Au mineralisation [1,3].
METAMORPHISM	
Metamorphic grade	Upper-greenschist facies [3].
STRUCTURAL SETTING	
Structural style	Ductile-brittle [3].
Closest major shear	An E-W trending major shear zone ? [2,3].
Controlling structure	A shear zone in the contact between quartzite and metavolcanic rocks, the controlling shear zone is within the E-W trending major shear zone ? [2,3].
Veins	Pyrite-bearing quartz veins, concentrated in the contact zone between dolerite and quartzite [1].
ALTERATION	
General alteration	Formation of sheared quartz-carbonate-biotite-chlorite-pyrite rock [2,3].
GENETIC MODEL	All mineralogical and textural data [1,2,3] suggest epigenetic mesothermal origin, mineralisation under mid- or upper-greenschist facies conditions during metamorphism.
FIGURES	[3]: Local geology map, magnetic anomaly map, drilling profile.

References

1. Sarala, P. 1995. Maaperägeokemiallinen malminetsintä Petäjävaaran ja Vammavaaran alueilla, Etelä-Lapissa, vuosina 1992-1995. Summary: Prospecting studies in Petäjävaara and Vammavaara areas during 1992-1995, southern Finnish Lapland. Geological Survey of Finland, unpublished report M19/2633/-95/1/10. 19 p.
2. Rossi, S. 1998. Personal communication on 14/8/1998.
3. Sarala, P. & Rossi, S. 1998. Kupari- ja kultapitoisen hiertovyöhykkeen paikantaminen moreenigeokemiallisin tutkimuksin Peräpohjan liuskealueelta Pohjois-Suomessa. Summary: Discovery of a copper- and gold-bearing shear zone as a result of research into the till geochemistry of the Peräpohja Schist Belt, northern Finland. Geological Survey of Finland, Report of Investigation 142. 44 p.

Name	***Sivakkajoki***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Lapland **Belt** Peräpohja Schist Belt
Map sheet	2631 10 **X coordinate** 7346900 **Y coordinate** 2536500
Municipality	Tervola
Nearest town, access	15 km N from Tervola, 50 km SW from Rovaniemi city. 10 km from a sealed road, 15 km from Highway 4, a gravel road to the area.
MINING	
Exploration licence no.	4796/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK) (1983-93), Outokumpu Oyj (1960s-1970s).
Status of development	Prospect.
Best sections	1 m at 2.19 ppm Au, 1 m at 1.5 ppm Au [4].
Extent of mineralisation	Potentially mineralised domain at surface, as defined by the extent of alteration: 2-20 m wide, >100 m long [4,5].
EXPLORATION	
Discovery	By GTK: Au anomalies in till detected on 1984-1990; these led to the discovery of mineralised areas in bedrock on 1991 [5].
Exploration history	Outokumpu Oyj (1960s-1970s) [5]. bedrock mapping, diamond drilling as a part of regional exploration around the Kivimaa deposit. GTK (1983-1993) [1,2,3,4,5]: survey of glacial erratic boulders, bedrock mapping, bedrock surface sampling by drilling, till stratigraphy and geochemistry, IP ground survey, trenching, diamond drilling, thin section investigations, low-altitude airborne magnetic, electromagnetic, radiometric and gravity survey.
Drilling	GTK (1991-): 12 diamond-drill holes, total 443 m [4]. Outokumpu: two diamond-drill holes [5].
Elements analysed	By XRF: major elements, by ICP: Co, Cu, Ni, Pb, Zn, by GFAAS: Au, Pd, Te [4].
Geophysical response	Irregular response with IP [4].
Secondary dispersion	The Au-till anomaly is about 1 km long, located to the W and SW of the Kivimaa deposit, and interpreted not to be related to the mined deposit, but to the Sivakkajoki mineralisation [1,2,3,4]. According to a factor analysis, a good positive correlation between Au and Te in till [3,4].
Exploration geologist(s) in charge	GTK: Seppo Rossi.
ORE	
Siting of gold	Apparently, only in quartz veins [5].
Major opaques	Pyrite, chalcopyrite [4].
Gangue	Quartz, calcite [4].
Ore composition	Diamond-drill core [4]: 2.19 ppm Au, 86 ppm Co, 8 ppm Cu, 436 ppm Ni, <0.01 ppm Pd, 33 ppm Pb, 0.17 ppm Te, 56 ppm Zn [4].
Enriched elements	Au, CO_2, Cu, K, Te [4].
GEOLOGY	
Major host rocks	Dolerite sill [4,5].
Geological setting	Chiefly conformable, 2.2 Ga, dolerite dikes in a sequence of mafic and, possibly, ultramafic metavolcanic rocks and quartzites of the Peräpohja Schist Belt [4,5].
Intrusives	Differentiated, 2.2 Ga, dolerites which predate Au mineralisation [1,2,3,4].
METAMORPHISM	
Metamorphic grade	Upper-greenschist facies: interpreted from [1,2,3,4].
Metamorphic mineral assemblage	Dolerite: actinolitic hornblende-albite-magnetite [4].
STRUCTURAL SETTING	
Structural style	Brittle [4,5].
Controlling structure	A shear zone or a set of shear zones in the dolerite-metavolcanic rock sequence, parallel to the strike of bedding in the area [4,5].
Veins	Quartz-carbonate, quartz and carbonate veins and vein networks variably containing sulphides [4,5].
ALTERATION	
General alteration	Carbonation, biotitisation, sulphidation (pyrite dissemination), formation of talc [4]. The along-strike extent of altered rocks is several hundreds of metres enveloping a network of quartz-carbonate veins, width of the altered domain is 2-20 m [4]. Extent: 2-20 m wide, >100 m long domain of alteration [5].
Proximal alteration	Mafic rock (typical dolerite): biotite-carbonate-quartz ± pyrite [4]. Ultramafic rock (differentiate of the dolerite): talc-carbonate ± biotite ± pyrite [4].

Distal alteration Typical dolerite: chlorite-carbonate-albite-quartz [4].

TIMING Post-2.2 Ga magmatism [5].

GENETIC MODEL All mineralogical and textural data, chiefly from [4], suggest epigenetic mesothermal origin; mineralisation took place under upper-greenschist facies conditions during regional metamorphism.

FIGURES [4]: Aerial photographs of the area.

References

1. Äyräs, M. 1988. Geokemiallisia kultatutkimuksia Peräpohjan liuskealueella. Annales Universitatis Turkuensis, Sarja C, Tom. 67, 89-88. (in Finnish)
2. Koivisto, T. 1984. Geokemialliset tarkistustutkimukset Peräpohjan liuskealueella: Moreenigeokemialliset kultatutkimukset Kivimaan ja Vinsan tunnettujen Cu-Au-juonimuodostumien ympäristössä. Tutkimusraportti nro 1. Geological Survey of Finland, unpublished report S/41/2544/1/1984. 19 p. (in Finnish)
3. Äyräs, M. 1991. Maaperägeokemialliset tutkimukset Tervolan Kivimaalla vuosina 1990-91. Geological Survey of Finland, unpublished report S/41/2631/1/1991. 16 p. (in Finnish)
4. Rossi, S. 1993. Kultalohkareaiheen malmitutkimukset Peräpohjan liuskealueella Sivakkajoen varressa Kivimaassa Tervolan kunnan luoteisosassa vuosina 1989-1992. Geological Survey of Finland, unpublished report M19/2631/-93/1/10. 33 p. (in Finnish)
5. Rossi, S. 1998. Personal communication on 14/8/1998.

Name	***Vinsa***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Lapland **Belt** Peräpohja Schist Belt
Map sheet	2633 03 **X coordinate** 7363200 **Y coordinate** 2547300
Municipality	Rovaniemi rural municipality
Nearest town, access	35 km SW from Rovaniemi city. 4 km from a sealed road, 15 km from Highway 4, a gravel road to the area.
MINING	
Exploration licence no.	1990/1, 2078/1, 3925/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oy (1966-1974), Geological Survey of Finland (GTK) (1983-86).
Status of development	Prospect.
Extent of mineralisation	About 0.2-5 m wide, widest where the vein is branching, >250 m long, vein deposit dipping to the east at 65° [1,2,7,8,10,11].
Lodes	One lode [1,2,7,10,11].
EXPLORATION	
Discovery	By Outokumpu on 1966: mineralised samples found by amateur prospectors led exploration to the area and the mineralisation was detected in outcrop [8,13].
Exploration history	Outokumpu (1966-1974) [5,8,10,11,12,13,14]: detailed bedrock mapping, till geochemical survey, trenching, ground magnetic, slingram, VLF-R and SP survey, diamond drilling, small-scale pilot plant tests. GTK (1983-1986) [1,2,3,4,6,7]: bedrock mapping, till stratigraphy and geochemistry, bedrock surface sampling by drilling, magnetic and ground VLF-R survey, diamond drilling.
Drilling	GTK [1]: 11 vertical diamond-drill holes, each extending 5-10 m into bedrock. Outokumpu (late 1960's) [8,10,11,12,13]: 9 diamond-drill holes, total 412 m.
Elements analysed	By AAS(?): As, Au, Cu [5]. By AAS: Ag, Co, Cu, Mn, Ni, Pb, and Zn; by GFAAS: Au, Pd, aqua regia leach for all analyses [1,2,3].
Geophysical response	A distinct magnetic and VLF-R anomaly [1,13].
Secondary dispersion	An extensive Au anomaly in till, extent roughly 0.5 x 2 km, but this is not related to the known major vein, as the anomaly is about 1 km SE from the vein; no significant mineralisation has been found to be directly related to the anomaly [1,2,3,4]. Possibly, a Cu anomaly in till [12].
Exploration geologist(s) in charge	Outokumpu: Pentti Rouhunkoski; GTK: Matti Äyräs, Seppo Rossi.
ORE	
Major opaques	Chalcopyrite, pyrite, pyrrhotite [1,2,4,5,6,7,8].
Minor opaques	Co pentlandite, sphalerite, mackinawite, tellurobismuth, hessite, native bismuth, native gold(?) [1,2,4,5,6,7,8].
Gangue	Quartz, tourmaline [1,2,3,4,6,8].
Ore composition	Average grade in the major, 1 m wide vein: 3 ppm Au, 3% Cu [1,2,3,4,5]. Bulk ore: 5.0% Cu, 11.8% Fe, 7.0% S, 4.0 ppm Au [10,11].
Enriched elements	Au, Bi, Co, CO_2, Cu, K, Rb, S, Te [1,2,3,4,8].
GEOLOGY	
Major host rocks	Dolerite (“albite diabase”) [1,2,3,4,5,8,9].
Geological setting	Conformable dolerite dikes in a sequence of quartzites and mafic metavolcanic rocks, in stratigraphically lower part of the volcano-sedimentary Peräpohja schist sequence [1,2,3,4,8].
Intrusives	Metamorphosed, Fe-tholeiitic, dolerite forms the host rock and predates mineralisation [1,2,5,8,9].
METAMORPHISM	
Metamorphic grade	Upper-greenschist facies: interpreted from the references 1-3 and 8.
Metamorphic mineral assemblage	Albite-actinolite-epidote-quartz-calcite [1,2,3,8].
STRUCTURAL SETTING	
Structural style	Brittle(-ductile) [1,2].
Ore fabric	Granoblastic [8].
Veins	One one-metre wide and several minor quartz veins containing minor amounts of sulphides, tourmaline and magnetite [1,2,3,5,10,11].
ALTERATION	
General alteration	Biotitisation and pyritisation [1,2,3,7,8]. Degree of carbonation is low [8].
GENETIC MODEL	Epigenetic, “mesothermal”, as interpreted from data given in [1,5,7,8].
FIGURES	[1,3]: Local surface geology map.
References	

1. Äyräs, M. 1987. On the geochemical gold prospecting at Vinsanmaa, northern Finland. Geological Survey of Finland, unpublished report S/41/2633/1/1987. 6 p.
2. Äyräs, M. 1987. Tutkimustyöselostus Rovaniemen maalaiskunnassa valtausalueella Vinsanmaa (Kaivosrekisterinro 3925/1) suoritetuista malmitutkimuksista. Geological Survey of Finland, unpublished report M06/2633/-87/1/30. 3 p. (in Finnish)
3. Äyräs, M. 1991. Geochemical prospecting at Vinsanmaa, northern Finland. Journal of Geochemical Exploration 39, 379-386.
4. Äyräs, M. 1988. Geokemiallisia kultatutkimuksia Peräpohjan liuskealueella. Annales Universitatis Turkuensis, Sarja C, Tom 67, 89-88. (in Finnish)
5. Rouhunkoski, P. & Isokangas, P. 1974. The copper-gold vein deposit of Kivimaa at Tervola, N-Finland. Bulletin of the Geological Society of Finland 46, 29-35.
6. Koivisto, T. 1984. Geokemialliset tarkistustutkimukset Peräpohjan liuskealueella: Moreenigeokemialliset kultatutkimukset Kivimaan ja Vinsan tunnettujen Cu-Au-juonimuodostumien ympäristössä. Tutkimusraportti nro 1. Geological Survey of Finland, unpublished report S/41/2544/1/1984. 19 p. (in Finnish)
7. Rossi, S. 1998. Personal communication on 14/8/1998.
8. Lehtinen, M. & Eilu, P. 1987. Diabaaseihin liittyvät malmiaiheet: Vinsa. In: H. Papunen (ed.) Lapin vulkaniittien tutkimusprojekti. Loppuraportti. Department of Geology, University of Turku, unpublished report. 341-346. (in Finnish)
9. Eilu, P. 1987. Diabaasikohteiden geokemiaa. In: H. Papunen (ed.) Lapin vulkaniittien tutkimusprojekti. Loppuraportti. Department of Geology, University of Turku, unpublished report. 365-385. (in Finnish)
10. Rouhunkoski, P. 1969. Vinsan malmijuoni Rovaniemen maalaiskunnassa. Outokumpu Oy, unpublished report 001/2633/PR/69. 2 p. (in Finnish)
11. Rouhunkoski, P. 1971. Rovaniemen maalaiskunta 6/Vinsa. Täydennysraportti. Outokumpu Oy, unpublished report 001/2633/PR/71. 3 p. (in Finnish)
12. Wennervirta, H. 1967. Moreenitutkimus, Rovaniemen maalaiskunta, Vinsa. Outokumpu Oy, unpublished report 062/2633/HW/67. 1 p. (in Finnish)
13. Isokangas, P. 1974. Kaivoslain 17§ edellyttämä tutkimusselostus suoritetuista töistä Rovaniemen mlk:ssa valtausalueella “Vinsanmaa 1”, kaivosrekisteri n:o 2078/1. Outokumpu Oy, unpublished report. 2 p. (in Finnish)
14. Isokangas, P. 1968. Kaivoslain 17§ edellyttämä tutkimusselostus suoritetuista töistä Rovaniemen mlk:ssa valtausalueella “Vinsanmaa 1”, kaivosrekisteri n:o 1990/1. Outokumpu Oy, unpublished report. 2 p. (in Finnish)

Name	***Ahveroinen***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Raahe-Haapajärvi
Map sheet	2341 12 **X coordinate** 7062770 **Y coordinate** 2539350
Municipality	Reisjärvi
Nearest town, access	8 km NW from Reisjärvi, 130 km SW from Oulu. A sealed road 2.5 km from the area, a gravel road 500 m from the area.
MINING	
Exploration licence no.	3691/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oyj (1984-1985).
Status of development	Prospect.
Best sections	0.15 m at 28.7 ppm Au, 4.3 ppm Ag and 0.1% Cu [1].
EXPLORATION	
Discovery	By a local blacksmith on 1887: visible gold detected in a quartz vein [1,5]. Several Au- and Ag-rich boulders found by the GTK on 1956 in the area. The mineralisation was detected by drilling into anomalies [4].
Exploration history	Outokumpu (1984-86) [1,5]: diamond drilling based on earlier till geochemical and geophysical surveys by the GTK and Outokumpu [2,3,4].
Drilling	Outokumpu: Six diamond-drill holes, total 630 m, in two profiles 100 m apart [1,5].
Elements analysed	Ag, As, Cu, Co, Fe, Ni, Pb, S, Zn, probably, by AAS [1].
Exploration geologist(s) in charge	
	Outokumpu: Tauno Huhtala, Esa Sandberg.
ORE	
Major opaques	Pyrite [1,5].
Gangue	Quartz [1,5].
GEOLOGY	
Major host rocks	Quartz-diorite [1,5].
Geological setting	A sequence of metavolcanic and metasedimentary rocks locally intruded by synorogenic granitoids.
Intrusives	Synorogenic granitoids within the area, these predate gold mineralisation [1,5].
METAMORPHISM	
Metamorphic grade	Amphibolite facies [5].
STRUCTURAL SETTING	
Closest major shear	The mineralisation is between two NW trending, large (1-2 km wide, >100 km long), shear zones which, in their part, define the trend of the Ladoga-Raahe Zone; the mineralisation is about 500 m SW from the nearest of these shear zones [3,5].
Veins	The gold mineralisation is in quartz vein(s) [1].
GENETIC MODEL	Orogenic “mesothermal” deposit.
FIGURES	[1]: Drilling sections. [2]: Drill hole plan.

References

1. Sandberg, E. 1986. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Reisjärvi, Ahveroinen. Outokumpu Oy, unpublished report 080/2431/EAS/86. 2 p. (in Finnish)
2. Sandberg, E. 1985. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Reisjärvi, Tiaiskurunkangas. Outokumpu Oy, unpublished report 080/2431/EAS/85. 3 p. (in Finnish)
3. Kokkola, M. & Pehkonen, E. 1976. Kangaskylä: gold in till. Journal of Geochemical Exploration 5, 239-244.
4. Pehkonen, E. 1959. Kultamalmitutkimukset Reisjärven pitäjän Kangaskylässä vuosina 1956-1958. Geological Survey of Finland, unpublished report M/19/RE-56-58/1. 12 p. (in Finnish)
5. Huhtala, T. 1984. Kairausraportti GTK:n ja OKME:n syväkairauksista Reisjärven Kangaskylässä 1958-1983. Outokumpu Oy, unpublished report 032/2341/TEH/84. 3 p. (in Finnish)

Name	***Ängeslampi***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Raahe-Haapajärvi
Map sheet	2433 02, 03 **X coordinate** 7113000 **Y coordinate** 2546000
Municipality	Haapavesi
Nearest town, access	20 km W from Haapavesi, 100 km SW from Oulu. A sealed road 3 km from the area, gravel roads to the area.
MINING	
Exploration licence no.	3891/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Resources	0.27 Mt 3.1 ppm Au [3,4].
Total in-situ gold	Min. 830 kg [3,4].
Best sections	3 m at 5.0 ppm Au. Highest Au contents in bedrock surface samples: 145, 95 and 28 ppm [3,4].
EXPLORATION	
Discovery	First indications: similar geophysical anomalies under a peat bog as for the Vesiperä mineralisation and glacial erratic boulders containing 5-20 ppm Au. These anomalies were checked by till and bedrock surface sampling; the latter indicated the presence of a Au mineralisation [3,4].
Exploration history	GTK: 1984-89: bedrock mapping, trenching, magnetic, electromagnetic and IP ground survey, geochemical and stratigraphic till mapping, percussion drilling, thin section investigations. Bedrock surface sampling with traverses in 50 m apart and samples 5-10 m apart, in total 900 samples. Not all bedrock surface anomalies were drilled [1,2,3,4,5].
Drilling	GTK [1988] [3,4]: 20 Diamond-drill holes, total 2671 m [3,4].
Elements analysed	Ag, As, Au, Bi, Co, Cu, Ni, Pb, Sb, Zn [3,4].
Geophysical response	The Au, As and Cu bedrock surface anomalies fit with the slingram anomaly in the S part but not in the N part of the area [3,4].
Primary dispersion	At bedrock surface, a consistent, 30-50 wide and more than 250 m long Au anomaly by using 0.1 ppm contour as the outer boundary. Arsenic and Cu form roughly equal anomalies to Au. The Au-As-Cu anomaly is open to the south. In the bedrock, Au has a positive correlation with Ag, As, Bi and Cu [3,4]. Au anomaly >20 ppb, slightly scattered, 100-200 m wide, >4 km long, defined by samples from partially weathered bedrock surface; also a local Cu-Co anomaly (>220 ppm Cu) and Pb and Ag anomalies of minor extent in the area [5].
Secondary dispersion	Scattered, but intense Au anomaly in till, located 0.5-1 km SE from the mineralisation [5].
Exploration geologist(s) in charge	
	GTK: Esko Sipilä.
ORE	
Major opaques	Pyrite, arsenopyrite [4,5].
Minor opaques	Chalcopyrite, tetrahedrite, rutile, fahlore, gold, TeBi(?) [4,5].
Gangue	Quartz, tourmaline(?) [4,5].
Ore composition	Average of 50-190 drill-core samples with 0.9 ppm cut off for Au [4]: Au 1.9 ppm, Ag 5.2 ppm, As 0.67 %, Co 46 ppm, Cu 1730 ppm, Ni 32 ppm, Pb 13.1 ppm, Sb 132 ppm, Zn 55 ppm.
	Diamond-drill core [3]: 2.65 ppm Au, 4.20 ppm Ag, 12000 ppm As, 12.8 ppm B, 500 ppm Ba, 33.1 ppm Bi, 23 ppm Co, 1490 ppm Cu, 82 ppb Hg, <1 ppm Mo, 20 ppm Ni, <2 ppm Pb, 72 ppm Rb, 30800 ppm S, 160 ppm Sb, 7.5 ppm Se, 456 ppm Sr, 1.500 ppm Te, 0.9 ppm Th, 0.5 ppm U, 220 ppm V, 6 ppm W, 79 ppm Zn; 49.7% SiO_2, 0.88% TiO_2, 17.6% Al_2O_3, 12.5% Fe_2O_3, 2.93% MgO, 5.80% CaO, 2.64% Na_2O, 2.45% K_2O, 0.26% P_2O_5, 3.62% LOI.
Enriched elements	Au + Ag, As, Bi, CO_2, Cu, Pb, S, Sb, Se, Te, W and Zn [1,3,4,5].
GEOLOGY	
Major host rocks	Plagioclase porphyry [3,4].
Geological setting	A sequence of metasedimentary and metavolcanic rocks within the Raahe-Ladoga Zone intruded by synorogenic granitoid plutons [4].
METAMORPHISM	
Metamorphic grade	Lower-amphibolite facies [3,4].
Metamorphic mineral assemblage	Plagioclase-hornblende-quartz-biotite-titanite [3,4].
STRUCTURAL SETTING	
Structural style	Ductile.
Closest major shear	To the NE of the mineralisation, about 500 m from the deposit, is a NW-striking, >100 km long major shear zone which is one of the main shear zones of the Raahe-Ladoga suture zone. Also the Kiimala, Pöhlölä and Vesiperä deposits are closely related to this shear zone [4].
GENETIC MODEL	An orogenic “mesothermal” mineralisation with a distinct structural control [4].

Post-mineralisation modifications

Weak, rertrograde, formation of sericite, chlorite, epidote and calcite.

FIGURES [5]: Au and Co anomalies in bedrock surface and in till.

References

1. Iisalo, E. 1987. Haapaveden Ängesnevan (Kiimalan) Au-, Cu-aiheen geokemialliset tutkimukset vuosina 1986-1987. Geological Survey of Finland, unpublished report S/4119/2433/1/87. 5 p. (in Finnish)
2. Kojonen, K. 1987. Monttutukimukset Haapaveden Vesiperällä, Ängesnevalla ja Veihtinevalla kesäkuussa 1987. Geological Survey of Finland, unpublished report M19/2433/78/1/51. 5 p. (in Finnish)
3. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey Finland, Bulletin 351. 101 p.
3. Sipilä, E. 1988. Kultatutkimukset valtausalueella Ängeslampi 1, Kaiv. Rek. n:o 3981/1. Geological Survey of Finland, unpublished report M06/2433/-88/1/10. 4 p. (in Finnish)
4. Sipilä, E. 1990. Kultamineralisaatioiden tutkimuksista Valtausalueilla Kiimala 1 ja 2 Haapavedellä 1988-1989. Geological Survey of Finland, unpublished report M19/2433/-90/3/10. 22 p. (in Finnish)
5. Iisalo, E. 1994. Kantokylän kohdentava geokemiallinen kartoitus ja sen tuottamat kulta- ja sulfidianomaliat. Geological Survey Finland, unpublished report S/41/2433/1/1994. 20 p. (in Finnish)

Name *Ängesneva (Kiimala 1)*

GENETIC TYPE	Orogenic 'mesothermal'.				
LOCATION					
Geological domain	Svecofennian	**Belt**	Raahe-Haapajärvi		
Map sheet	2433 02	**X coordinate**	7113920	**Y coordinate**	2546071
Municipality	Haapavesi				
Nearest town, access	20 km W from Haapavesi, 95 km SW from Oulu. A sealed road 4 km from the area, gravel roads to the area.				
MINING					
Exploration licence no.	4125/1.				
Present holder	OPEN FOR ACQUISITION.				
Previous holders	Geological Survey of Finland (GTK) (-1991).				
Status of development	Prospect.				
Resources	Above 150 m: 1.2 Mt, on average, 1.5 ppm Au [3,7].				
Total in-situ gold	1904 kg Au [3].				
Best sections	3.9 m at 3.7 ppm Au [3].				
Extent of mineralisation	Open at both ends and at the depth of 150 m [3].				
EXPLORATION					
Discovery	First indication: similar geophysical anomalies under a peat bog as for the Vesiperä mineralsiation. These anomalies were checked by till and bedrock surface sampling; the latter indicated the presence of a Au mineralisation [3].				
Exploration history	GTK (1984-91) [1,3,4,5,6,7]: bedrock mapping, trenching, magnetic, gravimetric, VLF-R, slingram, and IP ground survey, geochemical and stratigraphic till survey, percussion drilling down to the bedrock surface, thin section investigations.				
Drilling	Percussion drilling to the bedrock-till surface (1987-88) in 10 profiles 5-20 m apart; distance between drill holes 5-10 m [1,3,5]. Diamond drilling 1988-89: 46 holes, total 3557 m [1,3,7].				
Elements analysed	[8]: Main components, Cl, Sn and Zr by XRF; Ag, As, Au, Bi, Pd, Sb, Se and Te by GFAAS; Hg by wet-chemical method; B by DCP; Ba, Cd, Co, Cr, Ga, La, Li, Mo, Nb, Ni, Pb, Rb, Sb, Sc, Sr, Th, Tl, U, V, W, Y and Zn by ICP; S by Leco. Ag, Al, As, Au, B, Ba, Bi, Ca, Cd, Co, CO2, Cr, Cu, Fe, K, LOI, Mg, Mo, Na, Nb, P, Pb, Rb, REE, S, Sb, Sc, Se, Si, Sr, Te, Ti, Th, U, V, W, Y, Zn, Zr [2,3].				
Geophysical response	A slingram anomaly [1,3].				
Primary dispersion	Au anomaly >0.1 ppm: 250 x 30-50 m at bedrock surface. Geochemical bedrock Au and Cu anomalies: Au range 0.1-11 ppm and Cu 320-4700 ppm [3]. Au anomaly >20 ppb, slightly scattered, 100-200 m wide, >4 km long, defined by samples from partially weathered bedrock surface; also, a local Cu anomaly (>220 ppm) [6].				
Secondary dispersion	Scattered, but intense Au anomaly in till, located 0.5-1 km SE from the mineralisation [6].				
Exploration geologist(s) in charge					
	GTK: Esko Sipilä.				
ORE					
Siting of gold	Dominantly free gold with silicates associated with Bi and Te minerals. In addition, gold in electrum, tellurides and arsenopyrite, loellingite, tetrahedrite and chalcopyrite [4].				
Major opaques	Pyrrhotite and pyrite [4,5].				
Minor opaques	Arsenopyrite (±loellingite), chalcopyrite, digenite, bornite, sphalerite, chalcopyrite, tetrahedrite, tellurides, gold, electrum, bismuth, ilmenite, magnetite, haematite [2,3,4,5].				
Gangue	Quartz [4,5].				
Ore composition	Average of 32-70 drill-core samples with 0.9 ppm cut off for Au: Au 2.6 ppm, Ag 44.3 ppm, As 1.5 ppm(?), Co 110 ppm, Cu 5422 ppm, Ni 94.5 ppm, Pb 129 ppm, Zn 5974 ppm [3].				
	Diamond-drill core [8]: 2.65 ppm Au, 4.20 ppm Ag, 12000 ppm As, 12.8 ppm B, 500 ppm Ba, 33.10 ppm Bi, 23 ppm Co, 1490 ppm Cu, 82 ppb Hg, 35 ppm Li, <1.0 ppm Mo, 20 ppm Ni, <2 ppm Pb, 72 ppm Rb, 30800 ppm S, 0.16 ppm Sb, 7.50 ppm Se, 456 ppm Sr, 1.50 ppm Te, 0.9 ppm Th, 1.10 ppm Tl, 0.5 ppm U, 220 ppm V, 6 ppm W, 16 ppm Y, 79 ppm Zn, 65 ppm Zr; 49.7% SiO_2, 0.88% TiO_2, 17.6% Al_2O_3, 12.5% Fe_2O_3, 2.93% MgO, 5.80% CaO, 2.64% Na_2O, 2.50% K_2O, 0.26% P_2O_5.				
Enriched elements	Au, Ag, As, Bi, Cu, Hg, S, Te, W [3,8].				
GEOLOGY					
Major host rocks	Hypabyssal gabbro [2,3,7].				
Minor host rocks	Mica gneiss [5].				
Geological setting	The host rock gabbro is intruded into a sequence of mica schists and mafic metavolcanic rocks of Palaeoproterozoic age [2,3].				
Intrusives	Hypabyssal gabbro as host rock [2,3].				
METAMORPHISM					
Metamorphic history	Deformed and metamorphosed during 1900-1800 Ma [2,3].				
Metamorphic grade	Amphibolite facies [2,3].				

Metamorphic mineral assemblage	Plagioclase-hornblende-quartz [2,3].

STRUCTURAL SETTING

Structural style	Ductile.
Closest major shear	To the NE of the mineralisation, <100 m from the deposit, is a NW-striking, >100 km long major shear zone which is one of the main shear zones of the Raahe-Ladoga suture zone. Also the Ängeslampi, Pöhlölä and Vesiperä deposits are closely related to this shear zone [2,3].
Controlling structure	A set of en echelon shear zones with stockwork quartz veins and massive sulphide breccia are related togold mineralisation [2,3]. Stockwork quartz veins [2,3].

ALTERATION

General alteration	Silicification, sericitisation, “saussuritisation”, chloritisation and, locally, formation of K-feldspar porphyroblasts [2,3,4].
GENETIC MODEL	[4]: “.. the mafic host rock has offered a suitable Eh-pH environment for precipitation of the gold-rich hydrothermal solutions, which came through the shear and fault zones.” The composition of arsenopyrite suggests T = 400-450°C. Some of the Te-Bi mineral assemblages and native bismuth suggest lower temperatures, but these, most probably, are the result of post-precipitation exolution reactions. An orogenic “mesothermal” mineralisation with a distinct structural control.
FIGURES	[4]: Local surface geology map, cross section, ore photomicrographs. [5]: Regional geology map.

References

1. Iisalo, E. 1987. Haapaveden Ängesnevan (Kiimalan) Au-, Cu-aiheen geokemialliset tutkimukset vuosina 1986-1987. Geological Survey Finland, unpublished report S/4119/2433/1/87. 5 p. (in Finnish)
2. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey Finland, Bulletin 351. 101 p.
3. Sipilä, E. 1990. Kultamineralisaatioiden tutkimuksista Valtausalueilla Kiimala 1 ja 2 Haapavedellä 1988-1989. Geological Survey Finland, unpublished report M19/2433/-90/3/10. 22 p. (in Finnish)
4. Kojonen, K., Johansson, B. & Sipilä, E. 1991. The Kiimala gold deposit in Haapavesi, Western Finland. Geological Survey Finland, Special Paper 12, 75-79.
5. Iisalo, E. 1989. Haapaveden Kiimalan kulta-kupariaiheen geokemialliset tutkimukset vuosina 1987-89. Geological Survey Finland, unpublished report S/41/2433/1/1989. 13 p. (in Finnish)
6. Iisalo, E. 1994. Kantokylän kohdentava geokemiallinen kartoitus ja sen tuottamat kulta- ja sulfidianomaliat. Geological Survey Finland, unpublished report S/41/2433/1/1994. 20 p. (in Finnish)
7. Västi, K. 1991. Tutkimustyöselostus Haapaveden kunnassa valatusalueilla Kiimala 1, kaiv. rek. N:o 4125/1, ja Kiimala 2, kaiv. rek. N:o 4267/1, suoritetuista tutkimuksista. Geological Survey Finland, unpublished report 06/2433/-91/2/10. 3 p. (in Finnish)
8. Bornhorst, T. & Nurmi, P. (1999) Personal communication 20/1/1999.

Name	***Antikanperä***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Raahe-Haapajärvi
Map sheet	2433 03 **X coordinate** 7121050 **Y coordinate** 2546850
Municipality	Oulainen
Nearest town, access	10 km SE from Oulainen, 85 km SW from Oulu. A sealed road 5 km from the area, a gravel road to the area.
MINING	
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oyj, Geological Survey of Finland (GTK).
Status of development	Prospect.
EXPLORATION	
Exploration history	GTK(1986-1994) [1]: survey of glacial erratic boulders, bedrock mapping, geochemical till and bedrock surface sampling survey.
Primary dispersion	A scattered Au (>20 ppb) and Cu (>220 ppm) anomaly cluster, about 2 x 4 km in size, defined by partially weathered bedrock surface samples; also Pb anomalies of minor extent detected in the area [1].
Secondary dispersion	A scattered Au anomaly in till [1].
Exploration geologist(s) in charge	
	GTK: Esko Iisalo.
GEOLOGY	
Major host rocks	Mica schist [1].
Geological setting	Palaeoproterozoic mica schists intruded by synorogenic granitoids within the Raahe-Ladoga suture zone [1].
METAMORPHISM	
Metamorphic grade	Amphibolite facies [1].
STRUCTURAL SETTING	
Closest major shear	To the NE of the mineralisation, <2 km from the deposit, is a NW-striking, >100 km long major shear zone which is one of the main shear zones of the Raahe-Ladoga suture zone [1].
GENETIC MODEL	Orogenic “mesothermal” deposit.
FIGURES	[1]: Au and Co anomalies in bedrock surface and in till.

References

1. Iisalo, E. 1994. Kantokylän kohdentava geokemiallinen kartoitus ja sen tuottamat kulta- ja sulfidianomaliat. Geological Survey Finland, unpublished report S/41/2433/1/1994. 20 p. (in Finnish)

Name	***Antinoja***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Raahe-Haapajärvi
Map sheet	2342 05 **X coordinate** 7087730 **Y coordinate** 2510350
Municipality	Kannus
Nearest town, access	13 km W from Kannus, 120 km SW from Oulu. A sealed road 3 km from the area, a gravel road to the area.
MINING	
Exploration licence no.	4370/1, 3581/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oyj (1981-1984).
Status of development	Prospect.
Best sections	8.2 m at 3 ppm Au [2]. At least 30 sections of 1-8 m at >1 ppm Au [6].
EXPLORATION	
Discovery	On 1981: arsenopyrite- and chalcopyrite-rich glacial erratic boulder with 0.36% Cu and 129 ppm Au, found by an amateur prospector led Outokumpu to the mineralisation [2,6].
Exploration history	Outokumpu (1981-84) [2,5,6]: Bedrock mapping, glacial erratic boulder survey, till geochemistry, trenching, percussion and diamond drilling, ground magnetic, VLF and IP survey.
Drilling	Outokumpu (1983-84) [2]: 29 diamond-drill holes, total 2051 m, drilling profiles are 50-100 m apart.
Elements analysed	Ag, As, Au, Co, Cu, Mo, Rb, S, Sb, Th, U, W [6].
Geophysical response	IP anomalies are related to the mineralisation [2,6].
Secondary dispersion	Gold, As, Cu and Sb anomalies in till [5,6].
Exploration geologist(s) in charge	
	Outokumpu: Esa Sandberg, Markku Isohanni.
ORE	
Major opaques	Arsenopyrite [3,4,5,6].
Minor opaques	Pyrrhotite, chalcopyrite, gold [3,4,6].
Ore composition	Diamond-drill core [1]: 3.45 ppm Au, 0.214 ppm Ag, 80 ppm As, 11.7 ppm B, 291 ppm Ba, 0.5 ppm Bi, 8 ppm Co, 819 ppm Cu, 7 ppb Hg, 38 ppm Mo, 46 ppm Ni, <2 ppm Pb, 41 ppm Rb, 1420 ppm S, 0.9 ppm Sb, 0.34 ppm Se, 388 ppm Sr, 0.120 ppm Te, 1.0 ppm Th, 1.5 ppm U, 120 ppm V, <0.5 ppm W, 57 ppm Zn; 61.3% SiO_2, 0.51% TiO_2, 15.8% Al_2O_3, 5.91% Fe_2O_3, 3.21% MgO, 3.75% CaO, 6.17% Na_2O, 0.95% K_2O, 0.15% P_2O_5, 1.16% LOI.
Enriched elements	Ag, As, Au, Cu, Mo, S, Te [6].
GEOLOGY	
Major host rocks	Mafic metalava [1,2]. Intermediate metavolcanic rock [6].
Geological setting	The deposit is near the SE contact between the synorogenic Rautio batholith and its wallrocks [2,3,4].
Intrusives	The synorogenic (1.93-1.86 Ga) Rautio batholith is close (0.5-1 km) to the mineralisation [2,3,4,6].
METAMORPHISM	
Metamorphic grade	Amphibolite facies [2,3,4].
STRUCTURAL SETTING	
Controlling structure	A N-S trending shear zone? [2,6].
GENETIC MODEL	Orogenic “mesothermal” deposit (?). Factor analysis of lithogeochemical data suggests that Au mineralisation is unrelated to As-Cu-Co mineralisation in the area [6].
FIGURES	[2]: Bedrock map, IP anomaly map, drill hole location map, several drill sections.

References

1. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
2. Sandberg, E. 1985. Kaivoslain 19 pyk. mukainen tutkimustyöselostus. Kannus, Antinoja, Antinoja 2. Outokumpu Oy, unpublished report 080/2432/EAS/85. 4 p. (in Finnish)
3. Mäkelä, M., Sandberg, E. & Rantala, O. 1988. Proterozoic, gold-bearing vein occurrences associated with the granitoids in western Finland. In: A. D. T. Goode et al. (comp.) Bicentennial Gold 88, Melbourne, Victoria, May 16-20, 1988: Extended abstracts. Poster programme. 1. Geological Society of Australia. Abstracts Series 23, 153-155.
4. Mäkelä, M., Sandberg, E. & Rantala, O. 1988. Geochemical exploration of gold-bearing veins associated with granitoids in western Finland. In: D. R. MacDonald & K. A. Mills (eds) Prospecting in Areas of Glaciated Terrain - 1988: Papers presented at the Eighth International Symposium on Prospecting in Areas of Glaciated Terrain, Halifax, Nova Scotia, August 28 - September 3, 1988: Canadian Institute of Mining and Metallurgy. 255-270.
5. Sandberg, E. 1987. Kannuksen Antiojan ympäristön kullan raskasmineraalitutkimukset 1986. Outokumpu Oy, unpublished report 063/2342 02, 05/EAS/87. 3 p. (in Finnish)
6. Isohanni, M. 1984. Malminetsintötyöt Kannuksen Antiojalla. Outokumpu Oy, unpublished report 001/2342/MAI/84. 10 p. (in Finnish)

Name	***Hietajärvi***				
GENETIC TYPE	Orogenic ‘mesothermal’.				
LOCATION					
Geological domain	Svecofennian	**Belt**	Raahe-Haapajärvi		
Map sheet	2431 01	**X coordinate**	7107700	**Y coordinate**	2502700
Municipality	Kannus				
Nearest town, access	23 km W from Ylivieska. A sealed road 7 km from the area, a gravel road to the area.				
MINING					
Present holder	OPEN FOR ACQUISITION.				
Previous holders	Rautaruukki Oy (1960’s), Outokumpu Oyj (1980’s).				
Status of development	Prospect.				
Best sections	A few cases of 1 m at 2 ppm Au [1].				
EXPLORATION					
Discovery	On 1965: an auriferous erratic boulder discovered by an amateur prospector, led Rautaruukki to the mineralisation [1].				
Exploration history	Rautaruukki (1960’s) [1]: survey of glacial erratic boulders, bedrock mapping, diamond drilling.				
	Outokumpu (1980’s) [1]: bedrock mapping, percussion drilling, till geochemical survey, IP ground survey.				
Drilling	Rautaruukki (1960’s) [1]: 10 diamond-drill holes				
Exploration geologist(s) in charge					
	Rautaruukki: J. Talvitie, Outokumpu: Markku Isohanni, Esa Sandberg.				
ORE					
Major opaques	Arsenopyrite, pyrite, chalcopyrite, loellingite [1].				
GEOLOGY					
Major host rocks	Plagioclase-hornblende porphyry (= intermed. metavolc. rock?) [1].				
Minor host rocks	Mica schist [1].				
Geological setting	The deposit is near the SE contact between the synorogenic Rautio batholith and its wallrocks [1].				
Intrusives	The synorogenic (1.93-1.86 Ga) Rautio batholith is close (<1 km) to the mineralisation [1].				
STRUCTURAL SETTING					
Controlling structure	A N-S trending shear zone? [1].				
Veins	Auriferous, quartz ± sulphides veins, one to several tens of cm wide; also post-gold, barren quartz veins [1].				
GENETIC MODEL	Orogenic “mesothermal” deposit (?)				
Post-mineralisation modifications					
	Pegmatite granite dykes cut across the mineralisation [1].				

References

1.Sandberg, E. 1986 Kullanetsintätyöt Kannuksen Hietajärvellä v. 1984-1985, 2431 01. Outokumpu Oy, unpublished report 001/2431 01/ EAS/86. 4 p. (in Finnish)

Name	***Kangaskylä (Tiaiskurunkangas)***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Svecofennian **Belt** Raahe-Haapajärvi
Map sheet	2341 12 **X coordinate** 7064200 **Y coordinate** 2537970
Municipality	Reisjärvi
Nearest town, access	10 km NW from Reisjärvi, 130 km SW from Oulu. A sealed road 3 km from the area, a gravel road 500 m(?) from the area.
MINING	
Exploration licence no.	2251/1-2, 3270/1, 3371/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oyj (1971-1984), Geological Survey of Finland (GTK, 1956-1960).
Status of development	Prospect.
Best sections	1 m at 26.7 ppm Au, 0.79 % As and 0.44% Cu; 0.65 m at 35 ppm Au (a quartz vein); 1 m sections at 12 ppm, 4.8 ppm, 3.5 ppm and 2.0 ppm Au [4,8].
EXPLORATION	
Discovery	By a local blacksmith on 1887: visible gold in quartz vein [4]. Several Au- and Ag-rich boulders found by the GTK in 1956 [3]. The mineralisation was detected by drilling into anomalies [3].
Exploration history	GTK (1956-1960) [3]: drilling, bedrock mapping, trenching, thin and polished section investigations; geophysical ground survey: gravimetric, electric, magnetic; till geochemical survey. Outokumpu (1971-1984) [1,4,5,7,8]: Drilling, bedrock mapping, trenching; geophysical ground survey: gravimetry, magnetic, slingram and IP; till geochemical and stratigraphy survey, geochemical stream sediment survey.
Drilling	GTK (1958-1959): 32 diamond-drill holes [3,8]. Outokumpu (1972-1975, 1983-1985): 45 diamond-drill holes, total 5595 m [1,4,8].
Elements analysed	Ag, As, Au, Cu, Pb, Zn [4,8].
Geophysical response	Only by IP [4].
Secondary dispersion	Till and stream sediment anomalies for Au, As, Cu, Mo and W are ambiguous in the area [7].
Exploration geologist(s) in charge	Outokumpu: Eero Pehkonen Esa Sandberg, Tauno Huhtala.
ORE	
Siting of gold	Free gold in quartz veins, chiefly as inclusions in arsenopyrite and silicates [7].
Major opaques	Chalcopyrite, arsenopyrite, pyrite, pyrrhotite [1,8]
Minor opaques	Boulangerite, sphalerite, bournonite, gold [1,3,4,6,7,8].
Gangue	Quartz, scheelite, carbonate (calcite?), tourmaline [7].
Ore composition	Diamond-drill core [2]: 2.30 ppm Au,10.70 ppm Ag, 35000 ppm As, 14.2 ppm B, 3 ppm Ba, 3.5 ppm Bi, 15 ppm Co, 1320 ppm Cu, 180 ppb Hg, <1 ppm Mo, 13 ppm Ni, 33 ppm Pb, 45 ppm Rb, 22600 ppm S, 60 ppm Sb, 5.8 ppm Se, 259 ppm Sr, 2.250 ppm Te, <0.5 ppm Th, 2.0 ppm U, 32 ppm V, 15 ppm W, 496 ppm Zn; 64.1% SiO_2, 0.19% TiO_2, 13.6% Al_2O_3, 6.84% Fe_2O_3, 1.16% MgO, 2.79% CaO, 2.76% Na_2O, 2.38% K_2O, 0.076% P_2O_5, 0.85% LOI.
Enriched elements	Au, Ag, As, B, Bi, CO_2, Cu, Hg, K, Rb, S, Sb, Se, Te, W, Zn [2].
GEOLOGY	
Major host rocks	Mafic metalava [1,2,4,7].
Minor host rocks	Mica schist, granodiorite [1,2,4,7].
Geological setting	A sequence of metavolcanic and metasedimentary rocks locally intruded by synorogenic granitoids: the deposit is in the contact zone between the supracrustal rocks and the granitoid [6,7].
Intrusives	Synorogenic granitoids, 1.93-1.86 Ga of age, within the area; these predate gold mineralisation [1,4,6,7].
METAMORPHISM	
Metamorphic grade	Amphibolite facies [8].
STRUCTURAL SETTING	
Closest major shear	The mineralisations are between two NW trending large (1-2 km wide, >100 km long) shear zones which, in their part, define the trend of the Ladoga-Raahe Zone; the mineralisations are about 0.5-2 km SW from the nearest of these shear zones.
Veins	Auriferous quartz veins [1,3,4].
ALTERATION	
General alteration	Regional (retrogressive, post-gold?) epidotisation, sericitisation, chloritisation and carbonation; local, clearly Au-related alteration around the veins: carbonation, tourmalinisation, formation of muscovite and K feldspar [7].
GENETIC MODEL	Orogenic "mesothermal" deposit.
FIGURES	[4]: Drill hole location map, several drill sections.

References

1. Huhtala, T. 1977. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Reisjärvi, Lamminneva ja Tiaiskuru. Outokumpu Oy, unpublished report 26.11.1977. 1 p. (in Finnish)
2. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
3. Pehkonen, E. 1959. Kultamalmitutkimukset Reisjärven pitäjän Kangaskylässä vuosina 1956-1958. Geological Survey of Finland, unpublished report M/19/RE-56-58/1. 12 p. (in Finnish)
4. Sandberg, E. 1985. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Reisjärvi, Tiaiskurunkangas. Outokumpu Oy, unpublished report 080/2431/EAS/85. 3 p. (in Finnish)
5. Kokkola, M. & Pehkonen, E. 1976. Kangaskylä: gold in till. Journal of Geochemical Exploration 5, 239-244.
6. Mäkelä, M., Sandberg, E. & Rantala, O. 1988. Proterozoic, gold-bearing vein occurrences associated with the granitoids in western Finland. In: A. D. T. Goode et al. (comp.) Bicentennial Gold 88, Melbourne, Victoria, May 16-20, 1988: Extended abstracts. Poster programme. 1. Geological Society of Australia. Abstracts Series 23, 153-155.
7. Mäkelä, M., Sandberg, E. & Rantala, O. 1988. Geochemical exploration of gold-bearing veins associated with granitoids in western Finland. In: D. R. MacDonald & K. A. Mills (eds) Prospecting in Areas of Glaciated Terrain - 1988: Papers presented at the Eighth International Symposium on Prospecting in Areas of Glaciated Terrain, Halifax, Nova Scotia, August 28 - September 3, 1988: Canadian Institute of Mining and Metallurgy. 255-270.
8. Huhtala, T. 1984. Kairausraportti GTK:n ja OKME:n syväkairauksista Reisjärven Kangaskylässä 1958-1983. Outokumpu Oy, unpublished report 032/2341/TEH/84. 3 p. (in Finnish)

Name	***Käpykorpi***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Raahe-Haapajärvi
Map sheet	2432 09 **X coordinate** 7158010 **Y coordinate** 2528920
Municipality	Raahe
Nearest town, access	18 km S from Raahe, 55 km SW from Oulu. A sealed road 8 km from the area, a gravel road to the area.
MINING	
Exploration licence no.	3902/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oyj.
Status of development	Prospect.
Best sections	2 m at 1.2 ppm Au [1].
EXPLORATION	
Discovery	Auriferous glacial erratic boulders found on 1982, followed by the discovery of the mineralisation in outcrop in the same year by Outokumpu [1].
Exploration history	Outokumpu Oy (1982-1986): bedrock mapping, till and stream sediment geochemistry, survey of glacial erratic boulders, till stratigraphy, magnetic and IP ground survey, diamond drilling [1,3].
Drilling	Five diamond-drill holes, total 489 m, drilled into IP and geochemical anomalies [1].
Elements analysed	Ag, As, Au, Co, Cu, Fe, Ni, Pb, S, W, Zn
Geophysical response	An IP anomaly? [1].
Exploration geologist(s) in charge	
	Outokumpu: Esa Sandberg.
ORE	
Major opaques	Arsenopyrite [1].
Minor opaques	Loellingite, pyrite, gold [1].
Gangue	Quartz, scheelite [1].
GEOLOGY	
Major host rocks	Tonalite [1,2,3].
Minor host rocks	Mafic metavolcanic rock [1].
Geological setting	The mineralisation is in the contact zone of synorogenic granitoid and mafic metavolcanic rock [1].
Intrusives	1.93-1.86 Ga synorogenic tonalite hosting the mineralisation [2,3].
STRUCTURAL SETTING	
Closest major shear	The mineralisation is located between NW-trending major (>100 km long) shear zones of the Raahe-Ladoga suture zone [1,4].
GENETIC MODEL	Orogenic “mesothermal” deposit with a distinct structural control [1,2,3].

References

1. Sandberg, E. 1987. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Raahe, Käpykorpi. Outokumpu Oy, unpublished report 080/2432 09, 12/EAS/87 (in Finnish)
2. Mäkelä, M., Sandberg, E. & Rantala, O. 1988. Proterozoic, gold-bearing vein occurrences associated with the granitoids in western Finland. In: A. D. T. Goode et al. (comp.) Bicentennial Gold 88, Melbourne, Victoria, May 16-20, 1988: Extended abstracts. Poster programme. 1. Geological Society of Australia. Abstracts Series 23, 153-155.
3. Mäkelä, M., Sandberg, E. & Rantala, O. 1988. Geochemical exploration of gold-bearing veins associated with granitoids in western Finland. In: D. R. MacDonald & K. A. Mills (eds) Prospecting in Areas of Glaciated Terrain - 1988: Papers presented at the Eighth International Symposium on Prospecting in Areas of Glaciated Terrain, Halifax, Nova Scotia, August 28 - September 3, 1988: Canadian Institute of Mining and Metallurgy. 255-270.
4. Korsman, K., Koistinen, T., Kohonen, J., Wennerström, M., Ekdahl, E., Honkamo, M., Idman, H. & Pekkala, Y. (eds.) 1997. Suomen kallioperäkartta = Berggrundskarta över Finland = Bedrock map of Finland 1:1 000 000. Geological Survey of Finland.

Name	***Kiimala (Kiimala 2)***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Svecofennian **Belt** Raahe-Haapajärvi
Map sheet	2433 02 **X coordinate** 7114600 **Y coordinate** 2546620
Municipality	Haapavesi
Nearest town, access	20 km W from Haapavesi, 95 km SW from Oulu. A sealed road 4 km from the area, gravel roads to the area.
MINING	
Exploration licence no.	4267/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK) (-1991).
Status of development	Prospect.
Best sections	1 m at 9 ppm Au, 0.6 m at 13 ppm Au [7].
EXPLORATION	
Discovery	First indication: similar geophysical anomalies under a peat bog as for the Vesiperä mineralisation. These anomalies were checked by till and bedrock surface sampling; the latter indicated the presence of a Au mineralisation [3].
Exploration history	GTK: 1984-91 [1,3,4,5,7]: Bedrock mapping, trenching, magnetic, gravimetric, VLF-R, slingram and IP ground survey, geochemical and stratigraphic till mapping, percussion drilling down to the bedrock, thin section investigations.
Drilling	GTK (1988-1989): 11 diamond-drill holes, total 1217 m [7].
Elements analysed	Ag, Al, As, Au, B, Ba, Bi, Ca, Cd, Co, CO_2, Cr, Cu, Fe, K, LOI, Mg, Mo, Na, Nb, P, Pb, Rb, REE, S, Sb, Sc, Se, Si, Sr, Te, Ti, Th, U, V, W, Y, Zn, Zr [2,3].
Geophysical response	Geochemical till and bedrock-surface Au and Cu anomalies have a positive correlation with the slingram anomaly [1,3].
Primary dispersion	Au anomaly >0.1 ppm: 250 x 30-50 m at bedrock surface. Geochemical bedrock Au and Cu anomalies: Au range 0.1-11 ppm and Cu 320-4700 ppm [3]. Au anomaly >20 ppb, slightly scattered, 100-200 m wide, >4 km long, defined by samples from partially weathered bedrock surface; also, a local Cu anomaly (>220 ppm) [5].
Secondary dispersion	Scattered, but intense Au anomaly in till, located 0.5-1 km SE from the mineralisation [5].
Exploration geologist(s) in charge	GTK: Esko Sipilä.
ORE	
Siting of gold	Dominantly free gold apparently associated with pyrrhotite [7].
Major opaques	Pyrrhotite and pyrite [2,3].
Minor opaques	Chalcopyrite, sphalerite [7].
Ore composition	Diamond-drill core [2]: 2.65 ppm Au, 11.20 ppm Ag, 330 ppm As, 70 ppm B, 318 ppm Ba, 4.2 ppm Bi, 99 ppm Co, 2860 ppm Cu, 15 ppb Hg, <1 ppm Mo, 134 ppm Ni, 78 ppm Pb, 62 ppm Rb, 120000 ppm S, 34 ppm Sb, 10 ppm Se, 126 ppm Sr, 0.850 ppm Te, 1.8 ppm Th, 0.7 ppm U, 130 ppm V, 1 ppm W, 2920 ppm Zn; 33.9% SiO_2, 0.40% TiO_2, 10.1% Al_2O_3, 38.0% Fe_2O_3, 3.79% MgO, 3.33% CaO, 1.46% Na_2O, 0.91% K_2O, 0.023% P_2O_5, 8.16% LOI.
Enriched elements	Au, Ag, As, B, Bi, Cu, Hg, Fe(?), K, Rb, S, Sb, Se, Te, Zn [2,3].
GEOLOGY	
Major host rocks	Hypabyssal gabbro [2,3,7].
Geological setting	The host rock is intruded into a sequence of mica schists and mafic metavolcanic rocks of Palaeoproterozoic age [2,3].
Intrusives	Hypabyssal gabbro as host rock [2,3].
METAMORPHISM	
Metamorphic history	Deformed and metamorphosed at 1900-1800 Ma [2,3].
Metamorphic grade	Amphibolite facies [2,3].
Metamorphic mineral assemblage	Plagioclase-hornblende-quartz [2,3].
STRUCTURAL SETTING	
Structural style	Brittle-ductile [2,3].
Closest major shear	To the NE of the mineralisation, <100 m from the deposit, is the margin of a NW-striking, >100 km long major shear zone which is one of the main shear zones of the Raahe-Ladoga suture zone. Also the Ängeslampi, Pöhlölä and Vesiperä deposits are closely related to this shear zone [2,3].
Controlling structure	Gold mineralisation is in a set of minor, en echelon shear zones [2,3].
Veins	A set of auriferous, stockwork, quartz veins and massive sulphide breccia [2,3].
GENETIC MODEL	An orogenic "mesothermal" mineralisation with a distinct structural control. The composition of arsenopyrite suggests T = 400-450°C at Ängesneva, 1 km to the south of the Kiimala 2 [6].
FIGURES	[7]: Local geology map.

References

1. Iisalo, E. 1987. Haapaveden Ängesnevan (Kiimalan) Au-, Cu-aiheen geokemialliset tutkimukset vuosina 1986-1987. Geological Survey of Finland, unpublished report S/4119/2433/1/87. 5 p. (in Finnish)
2. Nurmi, P.A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
3. Sipilä, E. 1990. Kultamineralisaatioiden tutkimuksista Valtausalueilla Kiimala 1 ja 2 Haapavedellä 1988-1989. Geological Survey of Finland, unpublished report M19/2433/-90/3/10. 22 p. (in Finnish)
4. Iisalo, E. 1989. Haapaveden Kiimalan kulta-kupariaiheen geokemialliset tutkimukset vuosina 1987-89. Geological Survey of Finland, unpublished report S/41/2433/1/1989. 13 p. (in Finnish)
5. Iisalo, E. 1994. Kantokylän kohdentava geokemiallinen kartoitus ja sen tuottamat kulta- ja sulfidianomaliat. Geological Survey of Finland, unpublished report S/41/2433/1/1994. 20 p. (in Finnish)
6. Kojonen, K., Johansson, B. & Sipilä, E. 1991. The Kiimala gold deposit in Haapavesi, Western Finland. Geological Survey of Finland, Special Paper 12, 75-79.
7. Västi, K. 1991. Tutkimustyöselostus Haapaveden kunnassa valatusalueilla Kiimala 1, kaiv. rek. N:o 4125/1, ja Kiimala 2, kaiv. rek. N:o 4267/1, suoritetuista tutkimuksista. Geological Survey of Finland, unpublished report 06/2433/-91/2/10. 3 p. (in Finnish)

Name	***Laivakangas-N***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Svecofennian **Belt** Raahe-Haapajärvi
Map sheet	2441 07 **X coordinate** 7160400 **Y coordinate** 2528200
Municipality	Raahe
Nearest town, access	16 km SSE from Raahe, 50 km SW from Oulu. A sealed road 8 km from the area, a narrow gravel road to the area.
MINING	
Exploration licence no.	3181/1, 3463/1, 3649/1, 6122/1.
Present holder	Endomines Oy.
Previous holders	Outokumpu Oy (1980's).
Status of development	Prospect.
Resources	0.7 Mt 4 ppm Au [5].
Total in-situ gold	2.8 t Au [5].
Best sections	Several 0.4-1 m sections at 15-35 ppm Au [2].
Extent of mineralisation	A few metres wide and a few tens of metres long at surface [3].
EXPLORATION	
Discovery	An sample from a glacial erratic boulder found by an amateur prospector on 1980 [2,4].
Exploration history	Outokumpu Oy (1980's): bedrock mapping, till and stream sediment geochemical survey, survey of glacial erratic boulders, till stratigraphy, magnetic and IP ground survey, percussion and diamond drilling, pilot plant tests, thin section studies [2,3,4,6]. Endomines Oy: pilot plant tests.
Drilling	Outokumpu Oy (1980's): diamond drilling, total 6200 m [2]. Drilling in profiles, information from two profiles where each hole is about 20-30 m apart and the distance between profiles is 25 m [4].
Elements analysed	Major components by XRF; Ag, As, Au, Bi, Co, Cu, Fe, Hg, Ni, Pb, Te, Zn: by AAS; S by Leco [3].
Economic evaluations	Feasibility study by Outokumpu Oy on 1990(?) [4].
Primary dispersion	Good correlation between Au, As, Bi and Sb [2,3,6]. Other element pairs showing good mutual positive correlation are: Cu and Ag, As and Sb, and Te and Bi [3].
Secondary dispersion	A distinct stream sediment Au, As and Sb anomaly, and Au and As anomaly in till [6].
Exploration geologist(s) in charge	Outokumpu: Esa Sandberg, Endomines Oy: Timo Lindborg.
ORE	
Siting of gold	Gold occurs as native inclusions in quartz and other silicates (34%), and arsenopyrite and loellingite (64%), minor gold (2%) is in maldonite and as inclusions in chalcopyrite; most of gold is in the quartz veins [2,3,6].
Fineness	95% Au, 1.7% Ag (avg.) [2,6].
Major opaques	Arsenopyrite, loellingite [2,3,6].
Minor opaques	Pyrrhotite, chalcopyrite, pyrite, cubanite, marcasite, sphalerite, maldonite, bismuth, hedleyite, gold, molybdenite [2,3,6]
Gangue	Quartz, diopside, K-feldspar, plagioclase, biotite, scheelite [2,3,6].
Ore composition	Diamond-drill core [1]: 4.95 ppm Au, 2.100 ppm Ag, 2200 ppm As, 5.6 ppm B, 283 ppm Ba, 14.2 ppm Bi, 71 ppm Co, 451 ppm Cu, 52 ppb Hg, 2.0 ppm Mo, 36 ppm Ni, <1 ppm Pb, 66 ppm Rb, 2800 ppm S, <0.3 ppm Sb, 2.2 ppm Se, 202 ppm Sr, 1.850 ppm Te, 1.7 ppm Th, 0.5 ppm U, 280 ppm V, 28 ppm W, 92 ppm Zn; 54.1% SiO_2, 0.80% TiO_2, 15.2% Al_2O_3, 10.4% Fe_2O_3, 6.14% MgO, 8.51% CaO, 2.82% Na_2O, 1.56% K_2O, 0.14% P_2O_5, 0.85% LOI.
Enriched elements	Ag, As, Au, Bi, Hg, K (in mafic rock only), S, Se, Si(?), Te, W [1,3]
GEOLOGY	
Major host rocks	Quartz diorite and mafic metavolcanic rock [1,3].
Geological setting	The mineralisation is in the contact zone of late-orogenic(?) quartz diorite and mafic metavolcanic rock [2,3,5,6]. In a sequence of Palaeoproterozoic metavolcanic rocks intruded by synorogenic dykes, sills and plutons [5,6].
Intrusives	Quartz diorite dikes from the 1.93-1.86 Ga synorogenic pluton cross cut the metavolcanic rock, but predate mineralisation. Up to 20 cm wide, late-orogenic(?), granite dikes cross cut quartz diorite dikes and gold mineralisation [1,2,3,5,6].
METAMORPHISM	
Metamorphic grade	Amphibolite facies, 575±50°C, 5±0.5 kbar [3]. On the other hand, the presence of diopside indicates mid-amphibolite facies conditions. "Medium-grade" metamorphism in the reference [2].
Metamorphic mineral assemblage	Mafic metavolcanic rock: plagioclase-hornblende-biotite ± quartz, K feldspar, titanite, epidote, ilmenite [3]. Quartz diorite: plagioclase-hornblende-quartz-biotite ± K feldspar, titanite [3].
STRUCTURAL SETTING	
Structural style	Brittle-ductile [2,3].

Closest major shear	The mineralisation is located between NW-trending major (>100 km long) shear zones of the Raahe-Ladoga suture zone [5,6,7].
Controlling structure	A set of parallel, 1-150 cm wide, shear zones [2].
Veins	Auriferous arsenopyrite-quartz veins [1,2,3].
ALTERATION	
General alteration	Formation of epidote, biotite, K feldspar, quartz and arsenopyrite [3]. Alteration is, apparently, more intense in the mafic metavolcanic rock than in the quartz diorite [3].
Proximal alteration	Diopside-biotite-hornblende-plagioclase-K-feldspar-biotite-quartz-epidote assemblage; a diopside band forms the most proximal subzone, next to the veins, this is followed by a hornblende-dominated subzone [2,3,6].
TIMING	The deposit post-dates the intrusion of synorogenic quartz diorite, but predates late-orogenic(?) granite dikes [3].
GENETIC MODEL	Loellingite is surrounded by a arsenopyrite rim: the deposit is formed at temperatures where loellingite is stable, although arsenopyrite thermometry only gives 370°C [2]. Features described in [2,3,4,5,6] indicate an orogenic "mesothermal" mineralisation formed under amphibolite-facies PT conditions.
FIGURES	[3]: Local bedrock map, a trench map and outcrop photographs.

References

1. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
2. Mäkelä, M. & Sandberg, E. 1985. Raahen Laivakankaan kultaesiintymä. The gold occurrence at Laivakangas, Raahe. Geologi. 37, 5-8.
3. Mäkelä, M. 1984. Raahen Laivakankaan kvartsi-arseenikiisukultaesiintymä. Unpublished MSc thesis. University of Turku. 105 p. (in Finnish)
4. Korkalo, T. 1991. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Raahen kaupunki: Pirttihaudankangas, Siljanneva, Pirttivaara, Kauniinhaudansuo. Outokumpu Oy, unpublished report 080/2441, 2432/TTK/91. 3 p. (in Finnish)
5. Mäkelä, M., Sandberg, E. & Rantala, O. 1988. Proterozoic, gold-bearing vein occurrences associated with the granitoids in western Finland. In: A. D. T. Goode et al. (comp.) Bicentennial Gold 88, Melbourne, Victoria, May 16-20, 1988: Extended abstracts. Poster programme. 1. Geological Society of Australia. Abstracts Series 23, 153-155.
6. Mäkelä, M., Sandberg, E. & Rantala, O. 1988. Geochemical exploration of gold-bearing veins associated with granitoids in western Finland. In: D. R. MacDonald & K. A. Mills (eds) Prospecting in Areas of Glaciated Terrain - 1988: Papers presented at he Eighth International Symposium on Prospecting in Areas of Glaciated Terrain, Halifax, Nova Scotia, August 28 - September 3, 1988: Canadian Institute of Mining and Metallurgy. 255-270.
7. Korsman, K., Koistinen, T., Kohonen, J., Wennerström, M., Ekdahl, E., Honkamo, M., Idman, H. & Pekkala, Y. (eds.) 1997. Suomen kallioperäkartta = Berggrundskarta över Finland = Bedrock map of Finland 1:1 000 000. Geological Survey of Finland.

Name	***Laivakangas-S***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Svecofennian **Belt** Raahe-Haapajärvi
Map sheet	2432 09 **X coordinate** 7159890 **Y coordinate** 2527930
Municipality	Raahe
Nearest town, access	16 km S from Raahe, 50 km SW from Oulu. A sealed road 8 km from the area, a gravel road to the area.
MINING	
Exploration licence no.	3181/1, 3463/1, 3649/2, 6122/1.
Present holder	Endomines Oy.
Previous holders	Outokumpu Oy (1980's).
Status of development	Prospect.
Best sections	3.5 m at 5 ppm Au [1].
EXPLORATION	
Discovery	An sample from a glacial erratic boulder found by an amateur prospector on 1980 [2,4].
Exploration history	Outokumpu Oy (1980's): bedrock mapping, till and stream sediment geochemistry, survey of glacial erratic boulders, till stratigraphy, magnetic and IP ground survey, diamond drilling [2,4].
Exploration geologist(s) in charge	Outokumpu: Esa Sandberg.
ORE	
Major opaques	Arsenopyrite, loellingite [4].
Minor opaques	Gold [4].
Ore composition	Diamond-drill core [1]: 5.5 ppm Au, 0.590 ppm Ag, 580 ppm As, <0.5 ppm B, 566 ppm Ba, 38.8 ppm Bi, 11 ppm Co, 184 ppm Cu, 5 ppb Hg, 1 ppm Mo, 28 ppm Ni, <2 ppm Pb, 147 ppm Rb, 1690 ppm S, <0.2 ppm Sb, 0.88 ppm Se, 344 ppm Sr, 0.700 ppm Te, 5.8 ppm Th, 2.4 ppm U, 120 ppm V, 77 ppm W, 44 ppm Zn; 65.9% SiO_2, 0.49% TiO_2, 12.4% Al_2O_3, 5.90% Fe_2O_3, 3.40% MgO, 4.30% CaO, 2.76% Na_2O, 3.48% K_2O, 0.13% P_2O_5, 0.62% LOI.
Enriched elements	Au, Ag, As, Bi, K, Rb, S, Te, W [1].
GEOLOGY	
Major host rocks	Tonalite [1].
Geological setting	The mineralisation is in a sequence of Palaeoproterozoic metavolcanic rocks intruded by late-orogenic(?) dykes, sills and plutons [3,4].
Intrusives	1.93-1.86 Ga synorogenic tonalite hosting the mineralisation [3,4].
METAMORPHISM	
Metamorphic grade	Amphibolite facies [2,3,4].
STRUCTURAL SETTING	
Structural style	Brittle-ductile [2,3].
Closest major shear	The mineralisation is located between NW-trending major (>100 km long) shear zones of the Raahe-Ladoga suture zone [5].
Veins	Auriferous arsenopyrite-quartz veins in the narrow shear zones [4].
GENETIC MODEL	Features described in [2,3,4] indicate an orogenic "mesothermal" mineralisation formed under amphibolite-facies PT conditions.

References

1. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991 Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
2. Korkalo, T. 1991. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Raahen kaupunki: Pirttihaudankangas, Siljanneva, Pirttivaara, Kauniinhaudansuo. Outokumpu Oy, unpublished report 080/2441, 2432/TTK/91. 3 p. (in Finnish)
3. Mäkelä, M., Sandberg, E., Rantala, O. 1988. Proterozoic, gold-bearing vein occurrences associated with the granitoids in western Finland. In: A. D. T. Goode et al. (comp.) Bicentennial Gold 88, Melbourne, Victoria, May 16-20, 1988: Extended abstracts. Poster programme. 1. Geological Society of Australia. Abstracts Series 23, 153-155.
4. Mäkelä, M., Sandberg, E. & Rantala, O. 1988. Geochemical exploration of gold-bearing veins associated with granitoids in western Finland. In: ed. D. R. MacDonald & K. A. Mills Prospecting in Areas of Glaciated Terrain - 1988: Papers presented at the Eighth International Symposium on Prospecting in Areas of Glaciated Terrain, Halifax, Nova Scotia, August 28 - September 3, 1988: Canadian Institute of Mining and Metallurgy. 255-270.
5. Korsman, K., Koistinen, T., Kohonen, J., Wennerström, M., Ekdahl, E., Honkamo, M., Idman, H. & Pekkala, Y. (eds.) 1997. Suomen kallioperäkartta = Berggrundskarta över Finland = Bedrock map of Finland 1:1 000 000. Geological Survey of Finland.

Name	***Louetjärvi-Kukko***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Raahe-Haapajärvi
Map sheet	2342 05 **X coordinate** 7088700 **Y coordinate** 2514080
Municipality	Sievi
Nearest town, access	11 km W from Sievi, 120 km SW from Oulu. A sealed road 0.5-2 km from the area, gravel roads to the area.
MINING	
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	Best outcrop sample: 14.9 ppm Au, 1.28 % As [1].
EXPLORATION	
Discovery	On 1985 by GTK: arsenopyrite-bearing quartz veins detected in outcrop by a GTK geologist during regional exploration [1].
Exploration history	GTK (1985): outcrop mapping, diamond drilling [1].
Drilling	GTK (1985): 2 diamond-drill holes, total 53 m [1].
Elements analysed	As, Au, Co [1].
Exploration geologist(s) in charge	GTK: Esko Sipilä.
ORE	
Siting of gold	Gold seems to be only with arsenopyrite, very little gold in the veins if arsenopyrite is not present [1].
Major opaques	Arsenopyrite [1].
Gangue	Quartz, tourmaline [1].
GEOLOGY	
Major host rocks	Intermediate metatuffite [1].
Geological setting	A sequence of Palaeoproterozoic, fine-grained, volcanogenic metasedimentary rocks [1] .
Intrusives	About 2 km SE from the synorogenic Rautio batholith [1].
METAMORPHISM	
Metamorphic grade	Low-mid amphibolite facies.
STRUCTURAL SETTING	
Structural style	Ductile [1].
Controlling structure	Axial planes of late folding [1].
Veins	Arsenopyrite-bearing, dark, tourmaline-quartz veins in NE-trending axial plane. Abundant earlier, barren, tourmaline-quartz veins in other structural positions [1].
ALTERATION	
General alteration	No obvious wallrock alteration [1].
GENETIC MODEL	Orogenic “mesothermal” deposit.

References

1. Sipilä, E. 1989. Kultatutkimuksia Sievin Kukko-Louetjärven välisellä alueella. Geological Survey of Finland, unpublished report M19/ 2342/-89/1/10. 1 p. (in Finnish)

Name	***Oltava***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Raahe-Haapajärvi
Map sheet	2432 11 **X coordinate** 7149307 **Y coordinate** 2532355
Municipality	Pyhäjoki
Nearest town, access	20 km E from Pyhäjoki, 40 km SW from Oulu. A sealed road 6 km from the area, a gravel road to the area.
MINING	
Exploration licence no.	866, 942.
Present holder	Geological Survey of Finland (1997-).
Previous holders	Geological Survey of Finland (GTK) (1951-1953).
Status of development	Prospect.
Best sections	0.5 m at 10.9 ppm at, 3 m at 2.7 ppm Au, 17.6 m at 1.15 ppm Au [1,2].
Lodes	One of the lodes: length 8 m, width 2 m, open at depth of 28 m [4].
EXPLORATION	
Discovery	By GTK on 1951: gold-rich samples from boulders and outcrop, found during prospecting for Zn deposits and drilling in areas of electric anomalies [1,2].
Exploration history	GTK (1949-1953) [1,2,3]. Bedrock mapping, survey of glacial erratic boulders, electric and magnetic ground survey, thin and polished section investigations, diamond drilling. GTK (1998-) [4]: Bedrock mapping, diamond drilling.
Drilling	GTK (1951-1953) [1,2]: 20 diamond-drill holes, in total 2548 m.
Elements analysed	Au, Ag, Cu, Ni, Zn [1,2].
Exploration geologist(s) in charge	GTK, 1950’s: T. Borg; GTK 1990’s: Jarmo Nikander.
ORE	
Siting of gold	Native gold as inclusions in arsenopyrite and loellingite and as free with quartz [1,2,4].
Major opaques	Pyrrhotite [1,2]. Pyrite, molybdenite [4].
Minor opaques	Pyrite, arsenopyrite, sphalerite, chalcopyrite, loellingite, native gold [1,2,4].
Gangue	Quartz, tourmaline, diopside, tremolite, garnet, graphite [1,2].
GEOLOGY	
Major host rocks	Mica schist [4].
Minor host rocks	Black schist, felsic schist, amphibolite, “skarn bands” [1,2]. Quartz diorite [4].
Geological setting	The mineralisation is in the contact zone between a late-orogenic diorite and a mica schist [4].
Intrusives	Synorogenic quartz diorites and granites, aplite and pegmatite dikes, late-orogenic diorites and gabbros, and post-orogenic dolerites [1,2].
METAMORPHISM	
Metamorphic history	Progressive metamorphism after mineralisation (?): loellingite envelops arsenopyrite [1,2].
Metamorphic grade	Lower(?)-amphibolite facies [4].
Metamorphic mineral assemblage	Mica schist: quartz-biotite-muscovite ± plagioclase, baryte, tourmaline, pyrrhotite, chlorite [2,4]. Amphibolite: hornblende-plagioclase-biotite ± quartz, pyrrhotite, titanite [2,4]..
STRUCTURAL SETTING	
Structural style	Ductile(?).
Closest major shear	The mineralisation is located between NW-trending major (>100 km long) shear zones of the Raahe-Ladoga suture zone [4,5].
Controlling structure	A set of dextral faults or shear zones [4].
Veins	Auriferous, arsenopyrite-bearing tourmaline-quartz veins in an area covering about 2 ha [1,2,3].
ALTERATION	
Proximal alteration	Quartz veins have commonly hornblende or actinolite selvages [1,2]. Intense silicification of mica schist[4].
TIMING	The mineralisation post-dates the late-orogenic diorite [4].
GENETIC MODEL	A mesothermal mineralisation with a distinct structural control [4]. Gold mineralisation and granitic pegmatites have a genetic connection? [2].
FIGURES	[2]: Local bedrock map.

References

1. Borg, T. 1952, 1953, 1954. Geological Survey of Finland, unpublished reports M/52/PJ-52/1, M/17/PJ-53/2, M/17/PJ-54/1. 1 p., 5 p., 6 p. (in Finnish)
2. Pehkonen, E. 1953. Selostus Pyhäjoen Polusjärven alueen geologiasta. Geological Survey of Finland, Report M/17/PJ-53/3. 70 p. (in Finnish)
3. Stigzelius, H. 1953. Pyhäjoen Oltavan kultamalmiaihe. Comments on the Geological Survey of Finland, unpublished report M/17/PJ-53/2. Unpublished report M/17/PJ-53/4, Ministry of Trade and Industry. 5 p. (in Finnish)
4. Nikander, J. 1998. Personal communication 29/9/1998.
5. Korsman, K., Koistinen, T., Kohonen, J., Wennerström, M., Ekdahl, E., Honkamo, M., Idman, H. & Pekkala, Y. (eds.) 1997. Suomen kallioperäkartta = Berggrundskarta över Finland = Bedrock map of Finland 1:1 000 000. Geological Survey of Finland.

Name	***Pöhlölä***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Raahe-Haapajärvi
Map sheet	2433 02 **X coordinate** 7110580 **Y coordinate** 2548250
Municipality	Haapavesi
Nearest town, access	20 km W from Haapavesi, 100 km SW from Oulu. A sealed road to the area.
MINING	
Exploration licence no.	3835/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oyj (1984?-1987), Geological Survey of Finland (1987-?) (GTK).
Status of development	Prospect.
Best sections	0.6 m at 10.2 ppm Au, 0.6 m at 13.1 ppm Au, 0.6 m at 1.4% W [3,8].
EXPLORATION	
Discovery	Gold-bearing quartz veins and shear zones found in outcrop during regional gold exploration on 1984 by Outokumpu [3,8].
Exploration history	Outokumpu (1984-1986) [1,3,7,8]: geological mapping, IP ground survey, geochemical till and stream sediment survey, diamond drilling. GTK (1987-1994) [1,6]: bedrock mapping, trenching, magnetic, electromagnetic and IP ground survey, geochemical and stratigraphic till mapping, thin section investigations.
Drilling	Outokumpu (1984-1985) [1,3]: 16 diamond-drill holes, total 243 m; three drilling profiles, distance between the profiles 10 m and 60 m.
Elements analysed	Ag, As, Au, Co, Cu, Fe, Ni, Pb, S, Zn, W [3,7].
Primary dispersion	Au anomaly, >20 ppb, slightly scattered, 100-200 m wide, >4 km long, defined by samples from partially weathered bedrock surface [6]. Good positive correlation between Au and As [7].
Secondary dispersion	Scattered, but intense Au anomaly in till, located 0.5-1 km SE from the mineralisation [6].
Exploration geologist(s) in charge	Outokumpu: Esa Sandberg; GTK: Esko Iisalo, Kaj Västi.
ORE	
Siting of gold	Gold is only detected in the quartz veins [7].
Major opaques	Arsenopyrite [7].
Minor opaques	Gold, pyrrhotite [7].
Gangue	Quartz, scheelite [1,3,7]
Ore composition	Diamond-drill core (chiefly quartz vein material) [2]: 12.80 ppm Au, 2.10 ppm Ag, 630 ppm As, <0.5 ppm B, 295 ppm Ba, 314 ppm Bi, <1 ppm Co, 293 ppm Cu, 42 ppb Hg, 1 ppm Mo, 5 ppm Ni, 40 ppm Pb, 11 ppm Rb, 10800 ppm S, 0.9 ppm Sb, 2.8 ppm Se, 8 ppm Sr, 26.00 ppm Te, <0.5 ppm Th, <0.1 ppm U, 4 ppm V, 2400 ppm W, 141 ppm Zn; 96.2% SiO_2, 0.04% TiO_2, 0.3% Al_2O_3, 1.85% Fe_2O_3, 0.31% MgO, 0.19% CaO, 0.05% Na_2O, 0.14% K_2O, <0.002% P_2O_5, 0.85% LOI.
Enriched elements	Au, Ag, As, Bi, Hg, S, Se, Te, W [2,3,8].
GEOLOGY	
Major host rocks	Quartz diorite to tonalite [2,3,7,8].
Geological setting	The tonalite hosting the mineralisation has intruded into a Palaeoproterozoic volcano-sedimentary sequence [7].
Intrusives	Synorogenic, 1.93-1.86 Ga, calc-alkaline tonalite hosting the mineralisation [4,5,7,8].
METAMORPHISM	
Metamorphic grade	Lower-amphibolite facies (interpreted from [4,5,6,7,8]).
Metamorphic mineral assemblage	Tonalite: quartz-plagioclase-hornblende-biotite-titanite [7]. Mica schist: quartz-plagioclase-biotite-andalusite-garnet ± staurolite, cordierite
STRUCTURAL SETTING	
Structural style	Ductile.
Closest major shear	To the NE of the mineralisation, about 500 m from the deposit, is a NW-striking, >100 km long major shear zone which is one of the main shear zones of the Raahe-Ladoga suture zone. Also the Ängeslampi, Kiimala and Vesiperä deposits are closely related to this shear zone [3].
Controlling structure	A set of minor shear zones [3,7,8].
Ore fabric	Granoblastic [3].
Veins	A set of folded, auriferous, 0.5-10 cm wide quartz veins [3,7,8].
ALTERATION	
General alteration	Very little, if any, visible in outcrop [7].
TIMING	Mineralisation post-dates the intrusion of the synorogenic tonalite [7].
GENETIC MODEL	Orogenic “mesothermal” deposit.

Post-mineralisation modifications

Weak, rertrograde, formation of sericite, chlorite, epidote and calcite [7,8].

References

1. Iisalo, E. 1987. Haapaveden Ängesnevan (Kiimalan) Au-, Cu-aiheen geokemialliset tutkimukset vuosina 1986-1987. Geological Survey of Finland, unpublished report S/4119/2433/1/87. 5 p. (in Finnish)
2. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
3. Sandberg, E. 1986. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Haapavesi, Pölhölä. Outokumpu Oy, unpublished report 080/2433 02/EAS/86. 2 p. (in Finnish)
4. Mäkelä, M., Sandberg, E. & Rantala, O. 1988. Proterozoic, gold-bearing vein occurrences associated with the granitoids in western Finland. In: A. D. T. Goode et al. (comp.) Bicentennial Gold 88, Melbourne, Victoria, May 16-20, 1988: Extended abstracts. Poster programme. 1. Geological Society of Australia. Abstracts Series 23, 153-155.
5. Mäkelä, M., Sandberg, E. & Rantala, O. 1988. Geochemical exploration of gold-bearing veins associated with granitoids in western Finland. In: D. R. MacDonald & K. A. Mills (eds) Prospecting in Areas of Glaciated Terrain - 1988: Papers presented at he Eighth International Symposium on Prospecting in Areas of Glaciated Terrain, Halifax, Nova Scotia, August 28 - September 3, 1988: Canadian Institute of Mining and Metallurgy. 255-270.
6. Iisalo, E. 1994. Kantokylän kohdentava geokemiallinen kartoitus ja sen tuottamat kulta- ja sulfidianomaliat. Geological Survey of Finland, unpublished report S/41/2433/1/1994. 20 p. (in Finnish)
7. Mäkelä, M. 1986. Haapaveden Pöhlölä. Kvartsi-scheeliitti-kultaesiintymä tonaliittisessa intruusiossa. Keski-Pohjanmaan kultaprojekti. Raportti 5. Unpublished report. Department of Geology, University of Helsinki. 17 p. (in Finnish)
8. Sandberg, E. 1986. Haapavesi, Pöhlölä. Vuorimiesyhdistyksen geologijaoston ekskursio 30.9.1986. Outokumpu Oy, Malminetsintä, unpublished report. 2 p. (in Finnish)

Name	***Sarjankylä***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Raahe-Haapajärvi
Map sheet	2433 04 **X coordinate** 7104450 **Y coordinate** 2554100
Municipality	Nivala
Nearest town, access	14 km NE from Nivala, 110 km SW from Oulu. Sealed roads 2-4 km from the area, several gravel roads to the area.
MINING	
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Lodes	Auriferous quartz veins [1].
EXPLORATION	
Discovery	On 1930’s, by GTK(?): an outcrop sample with 131 ppm Au discovered during regional exploration [1].
Exploration history	GTK (1940’s, 1950’s) [1]: survey of glacial erratic boulders, bedrock mapping, trenching. GTK (1985) [1]: bedrock mapping, till geochemistry.
Elements analysed	Au, Ag [1].
Exploration geologist(s) in charge	GTK: Esko Sipilä.
ORE	
Siting of gold	Gold is related to arsenopyrite and loellingite, free gold occurs with silicates [1].
Major opaques	Arsenopyrite, loellingite [1].
Minor opaques	Chalcopyrite, pyrrhotite, pyrite, electrum or tellurides or both [1].
Gangue	Quartz, epidote (pre-gold?) [1].
GEOLOGY	
Major host rocks	Plagioclase porphyry, diorite [1].
Minor host rocks	Gabbro, granodiorite, felsic dyke [1].
Geological setting	A sequence of metasedimentary and metavolcanic rocks within the Raahe-Ladoga Zone intruded by synorogenic granitoid plutons [2].
Intrusives	A felsic dike cross cuts other intrusive rocks, but is mineralised as well [1].
METAMORPHISM	
Metamorphic grade	Lower- or mid-amphibolite facies [1].
Metamorphic mineral assemblage	Granodiorite, quartz diorite, gabbro: plagioclase-hornblende-biotite-K feldspar-quartz [1].
STRUCTURAL SETTING	
Closest major shear	To the NE of the mineralisation, max. 3m from the deposit, is a NW-striking, >100 km long major shearzone which is one of the main shear zones of the Raahe-Ladoga suture zone [2].
Controlling structure	Minor, mylonitic, shear zones(?) [1].
Veins	Auriferous quartz veins in all host rocks. Epidote present in a quartz vein in plagioclase porphyry, however a sulphidised mylonitic shear zone cross cuts the epidote-bearing veins [1].
GENETIC MODEL	Orogenic “mesothermal” deposit with a structural control [1].

References

1. Sipilä, E. 1990. Kultatutkimukset Nivalan Sarjankylässä 1985. Geological Survey of Finland, unpublished report M19/2433/-90/1/1. 8 p. (in Finnish)
2. Korsman, K., Koistinen, T., Kohonen, J., Wennerström, M., Ekdahl, E., Honkamo, M., Idman, H. & Pekkala, Y. (eds.) 1997. Suomen kallioperäkartta = Berggrundskarta över Finland = Bedrock map of Finland 1:1 000 000. Geological Survey of Finland.

Name	***Sipilä***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Raahe-Haapajärvi
Map sheet	2431 04 **X coordinate** 7109250 **Y coordinate** 2510000
Municipality	Kalajoki
Nearest town, access	15 km W from Ylivieska, 110 km SW from Oulu. A sealed road 500 m from the area, a gravel road to the area.
MINING	
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oyj (1987-), Geological Survey of Finland (GTK) (1986-1987).
Status of development	Prospect.
Best sections	0.5 m at 5.6 ppm Au, 60 ppm Ag and 9.4% Cu [2].
EXPLORATION	
Discovery	On 1986, an arsenopyrite-rich outcrop sample with 0.5% Co, found by an amateur prospector [2].
Exploration history	GTK (1986-1987) [1,2]: survey of glacial erratic boulders, bedrock mapping, IP ground survey, drilling into the IP anomaly, investigation of polished sections.
Drilling	GTK (1986): 4 drill holes, total 213 m [2].
Geophysical response	A 300 m long, ENE-striking IP anomaly [2].
Exploration geologist(s) in charge	GTK: Esko Sipilä.
ORE	
Siting of gold	“Invisible” gold in arsenopyrite [1,2].
Major opaques	Arsenopyrite, loellingite, chalcopyrite [1,2].
Minor opaques	Bornite, pyrrhotite, marcasite [1,2].
Enriched elements	Au, Ag, As, Co, Cu, S [1,2].
GEOLOGY	
Major host rocks	Mafic metalava [2].
Minor host rocks	Plagioclase porphyry [2].
Geological setting	The mineralisation is in a Palaeoproterozoic volcano-sedimentary sequence intruded by syn- and late-orogenic granitoids.
Intrusives	Synorogenic Rautio batholith, whose composition varies from granite to diorite and monzodiorite, is within 1-2 km from the mineralisation [2].
METAMORPHISM	
Metamorphic history	Mafic metalava: hornblende-diopside-plagioclase [2].
Metamorphic grade	Amphibolite facies [2].
STRUCTURAL SETTING	
Ore fabric	Sulphides occur chiefly as dissemination, but also as veins in the host rocks [1,2].
GENETIC MODEL	Orogenic “mesothermal” deposit. The strike of the mineralisation is nearly perpendicular to the dominant schistosity of the host rock [1,2].

References

1. Johanson, B. & Kojonen, K 1988. Raution kirkonkylän Co-mineraalit. Geological Survey of Finland, unpublished report M40/2431/-88/1/41.2. 1 p. (in Finnish)
2. Sipilä, E. 1989. Malmitutkimukset Urho Sipilän Co-pitoisen kallionäytteen johdosta Kalajoen Raution kylässä Geological Survey of Finland, unpublished report M19/2431/-89/1/10. 2 p. (in Finnish)

Name	***Vesiperä***				
GENETIC TYPE	Orogenic 'mesothermal'.				
LOCATION					
Geological domain	Svecofennian	**Belt**	Raahe-Haapajärvi		
Map sheet	2433 02	**X coordinate**	7111920	**Y coordinate**	2547540
Municipality	Haapavesi				
Nearest town, access	20 km W from Haapavesi, 100 km SW from Oulu. A sealed road 1-2 km from the area, gravel roads to the area.				
MINING					
Exploration licence no.	3853/1.				
Present holder	OPEN FOR ACQUISITION.				
Previous holders	Geological Survey of Finland (GTK).				
Status of development	Prospect.				
Resources	1988: 0.3 Mt with 2.5 ppm Au, 0.8 % As [4].				
Total in-situ gold	732 kg Au [4,5].				
Best sections	5 m at 9.4 ppm Au, 3 m at 5 ppm Au, 4.5 m at 2.2 ppm Au [4,5].				
Lodes	Several parallel, narrow, Au-mineralised zones [4,5].				
EXPLORATION					
Discovery	By Outokumpu on 1984: an arsenopyrite-rich sample from outcrop: 75 ppm Au, 15 % As (found by an amateur prospector). This led to the find of the so far biggest lode 250 m SSE from the first outcrop sample [4,5].				
Exploration history	GTK (1984-1988) [1,2,4,5,7]: bedrock mapping, trenching, magnetic, electromagnetic and IP ground survey, geochemical and stratigraphic till mapping, percussion drilling, thin section investigations. Diamond drilling during 1986-1988. Bedrock surface sampling with traverses 50 m apart and samples 5-10 m apart, in total 900 samples. Not all bedrock surface anomalies drilled.				
Drilling	GTK (1986-1988) [4,5]: diamond drilling, 34 holes, in total 2079 m within the area.				
Elements analysed	Ag, As, Au, Ba, Cd, Co, Cr, Cu, Fe, Mn, Ni, P, Pb, S, Sb, Zn. Locally, only As, Au and Fe or Au, Co, Cu, Ni, Pb and Zn. W analysed in a few cases [4,5].				
Geophysical response	Response on IP due to sulphide dissemination [4].				
Primary dispersion	Up to 100 m wide and 8 km long, linear, NW-SE striking, Au anomalies with K metasomatism, epidotisation and silicification (shear zones with alteration envelopes?). Au correlates with As [4]. An Au anomaly (>20 ppb), slightly scattered, 100-200 m wide, >4 km long, defined by samples from partially weathered bedrock surface; also, a local Cu-Co anomaly (>220 ppm Cu, >100 ppm Co) and Pb and Ag anomalies of minor extent in the area [7].				
Secondary dispersion	Scattered, but intense Au anomaly in till, located 0.5-1 km SE from the mineralisation [7].				
Exploration geologist(s) in charge					
	GTK: Esko Sipilä.				
ORE					
Siting of gold	With native bismuth and electrum, as inclusions in arsenopyrite and free grains, as inlusions and in fractures of silicates [4,5].				
Major opaques	Arsenopyrite, pyrrhotite, pyrite [4,5].				
Minor opaques	Marcasite, loellingite, chalcopyrite, ilmenite, rutile, gold, bismuth, electrum [4].				
Gangue	Quartz, tremolite-actinolite [4,5].				
Ore composition	Average of 32-70 drill-core samples with 0.9 ppm cut off for Au [4]: Au 4.8 ppm, Ag 1.9 ppm, As 1.27 %, Ba 73 ppm, Bi 6.7 ppm Cd 8.4 ppm, Co 55 ppm, Cr 22 ppm, Cu 443 ppm, Fe 4.99 %, Mn 393 ppm, Ni 19 ppm, P 933 ppm, Pb 11.6 ppm, Sb 19.5 ppm, Zn 51.5 ppm.				
Enriched elements	Au, Ag, As, Bi, Cu, K, Pb, Rb, S, Sb, Te, W and Zn [3,4].				
	Diamond-drill core [3]: 9.10 ppm Au, 1.80 ppm Ag, 13000 ppm As, 11.6 ppm B, 373 ppm Ba, 3.1 ppm Bi, 17 ppm Co, 279 ppm Cu, 29 ppb Hg, <1 ppm Mo, 18 ppm Ni, <2 ppm Pb, 54 ppm Rb, 2000 ppm S, 6.9 ppm Sb, 2.6 ppm Se, 551 ppm Sr, 0.440 ppm Te, 0.7 ppm Th, 0.6 ppm U, 200 ppm V, 92 ppm W, 95 ppm Zn; 50.6% SiO_2, 0.81% TiO_2, 18.0% Al_2O_3, 9.76% Fe_2O_3, 3.28% MgO, 6.74% CaO, 3.43% Na_2O, 1.77% K_2O, 0.24% P_2O_5, 2.08% LOI.				
GEOLOGY					
Major host rocks	Hypabyssal gabbro [3,4,6].				
Geological setting	The host rock is intruded into a sequence of Palaeoproterozoic metasedimentary and metavolcanic rocks [4].				
Intrusives	Hypabyssal gabbro: hosts the mineralisation [4].				
METAMORPHISM					
Metamorphic grade	Amphibolite facies [4].				
Metamorphic mineral assemblage	Gabbro: plagioclase-hornblende-quartz-biotite-titanite (+ minor retrograde sericite, chlorite, epidote and carbonate); mica schist: quartz-biotite-K feldspar-muscovite [4, 5].				
STRUCTURAL SETTING					
Structural style	Ductile.				
Closest major shear	To the NE of the mineralisation, about 500 m from the deposit, is a NW-striking, >100 km long major shear zone which is one of the main shear zones of the Raahe-Ladoga suture zone. Also the Ängeslampi, Pöhlölä and Kiimala deposits are closely related to this shear zone [4,5,6].				

Controlling structure Mineralisation is related to at least two, parallel, NW-striking shear zones [4,5,6].

Ore fabric Granoblastic [4,5].

Veins Locally, auriferous quartz±sulphide veins [4].

ALTERATION

General alteration Silicification, sericitisation, chloritisation and, in places, formation of K-feldspar phenocrysts or tremolite-actinolite [4,5].

GENETIC MODEL An orogenic "mesothermal" mineralisation with a distinct structural control [6].

Post-mineralisation modifications

Weak, retrograde, formation of sericite, chlorite, epidote and calcite [4,5].

FIGURES [7]: Au and Co anomalies in bedrock surface and in till.

References

1. Iisalo, E. 1987. Haapaveden Ängesnevan (Kiimalan) Au-, Cu-aiheen geokemialliset tutkimukset vuosina 1986-1987. Geological Survey Finland, unpublished report S/4119/2433/1/87. 5 p. (in Finnish)
2. Kojonen, K. 1987. Monttutukimukset Haapaveden Vesiperällä, Ängesnevalla ja Veihtinevalla kesäkuussa 1987. Geological Survey Finland, unpublished report M19/2433/78/1/51. 5 p. (in Finnish)
3. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
4. Sipilä, E. 1988. Kultatutkimukset Haapaveden Vesiperällä ja sen ympäristössä 1985-1988. Geological Survey Finland, unpublished report M19/2433/-88/1/10. 4 p. (in Finnish)
5. Västi, K. 1991. Tutkimustyöselostus Haapaveden kunnassa valatusalueella Vesiperä 1, kaiv. rek. nro. 3853/1, suoritetuista malmi-tutkimuksista. Geological Survey of Finland, unpublished report M06/2433/-91/1/10. 3 p. (in Finnish)
6. Weihed, P. & Mäki, T. 1997. Volcanic hosted massive sulfide deposits and gold deposits in the Skellefte district and Western Finland. Geological Survey of Finland, Guide 41. 81 p.
7. Iisalo, E. 1994. Kantokylän kohdentava geokemiallinen kartoitus ja sen tuottamat kulta- ja sulfidianomaliat. Geological Survey of Finland, unpublished report S/41/2433/1/1994. 20 p. (in Finnish)

Name	***Haasiakangas***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Southern Ostrobothnia
Map sheet	2331 03 **X coordinate** 7002455 **Y coordinate** 2504100
Municipality	Alajärvi
Nearest town, access	13 km ESE from Vimpeli. 8 km from a sealed road, 500 m from a gravel road.
MINING	
Present holder	OPEN FOR ACQUISITION.
Previous holders	Suomen Malmi Oy, Outokumpu Oyj, Geological Survey of Finland (GTK).
Status of development	Prospect.
EXPLORATION	
Exploration history	GTK (1981-86) [1]: Regional and localised till geochemistry, till stratigraphy and bedrock mapping.
Exploration geologist(s) in charge	
	GTK: Jarmo Nikander.
GEOLOGY	
Geological setting	A sequence of Palaeoproterozoic metasedimentary and metavolcanic rocks intruded by the granitoids of the Central Finland Batholith [1,2].
STRUCTURAL SETTING	
Closest major shear	Western contact of the Central Finland Batholith(?) [2].
GENETIC MODEL	Orogenic “mesothermal” deposit ?

References

1. Lestinen, P. 1998 Personal communication 8/10/1998.
2. Korsman, K., Koistinen, T., Kohonen, J., Wennerström, M., Ekdahl, E., Honkamo, M., Idman, H. & Pekkala, Y. (eds.) 1997. Suomen kallioperäkartta = Berggrundskarta över Finland = Bedrock map of Finland 1:1 000 000. Geological Survey of Finland.

Name	***Kalliosalo (Kallionsalo)***
GENETIC TYPE	Orogenic ‘mesothermal’ of Au-Sb subtype.
LOCATION	
Geological domain	Svecofennian **Belt** Southern Ostrobothnia
Map sheet	2222 07 **X coordinate** 6958900 **Y coordinate** 2446400
Municipality	Nurmo
Nearest town, access	8 km SE from Seinäjoki. 4 km to a sealed road, 1 km to a gravel road.
MINING	
Exploration licence no.	2495/1, 2554/1-2.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Malmikaivos Oy (1980-1982), Geological Survey of Finland (GTK) (1977-1980, 1986-1994).
Status of development	Prospect.
Resources	0.3 Mt with 0.85% Sb, 0.7 ppm Ag and 1.0 ppm Au [6,7]. 0.46 Mt with 0.73% Sb [3,10].
Total in-situ gold	300 kg [6,7].
Best sections	1 m at 25 ppm Au, 3 m at 10 ppm Au, 5 m at 1.3 ppm Au; 5 m at 0.54% Sb [3].
Extent of mineralisation	>250 m long, 10-35 m wide lodes [3,10].
EXPLORATION	
Discovery	Sb-rich erratic boulders found by amateur prospectors led to discovery of a Sb-mineralisation in outcrop on 1977 by the GTK [10,11]. Also, outcrop samples were receiveed 1991 from another lode, from an area where exploration for Sb has been done in since 1936. As a result, several Sb-mineralisations have been found, but not systematically checked for gold before 1980’s [3,4,10]. The Kalliosalo Au-Sb-rich mineralisation was detected in a road aggregate quarry on 1991.
Exploration history	Malmikaivos Oy (1980-1989) [5,6,8,9]: Bedrock mapping, diamond drilling, pilot plant tests (bacterial leaching, flotation). GTK (1936-1991) [3,4,10,11,12]: Detailed bedrock mapping, regional and local till stratigraphy and geochemistry, airborne and ground magnetic, electric and IP survey, channel sampling, diamond and percussion drilling, detailed ore mineralogy study; exploration for Sb since 1930’s, exploration only for Sb until 1982, exploration for Au and Sb from 1982.
Drilling	Malmikaivos Oy (1980-1989) [7]: Diamond-drill holes, total 3954 m. GTK (1977-1982) [10]: Diamond-drill 34 holes, total about 5000 m. GTK (1992) [3]: percussion drilling in profiles 20 m apart, across the strike of the main mineralised shear zone.
Elements analysed	As, Au, Sb [3]; Au, Pb, Sb, W [10].
Economic evaluations	Feasibility study by Malmikaivos Oy 1989 [7,8].
Geophysical response	Magnetic anomalies of small extent within the area, but these are not directly related to the mineralisations; no response with other methods tested [10].
Secondary dispersion	Extensive Au anomalies in the region in till, but the Kalliosalo mineralisation is only reflected by one anomalous point within the local Au pattern; strong, but local Sb and a moderate, local W anomaly [2,10]. Regional Sb and As anomalies in till are, apparently, unrelated to gold mineralisation [12].
Exploration geologist(s) in charge	Malmikaivos Oy: Matti Tyni; GTK: Panu Oivanen, Niilo Kärkkäinen.
ORE	
Siting of gold	Most of gold is in aurostibite, but a significant amount also is as native-gold inclusions in loellingite-arsenopyrite grains [3,4].
Major opaques	Arsenopyrite [4].
Minor opaques	Native antimony, loellingite, stibnite, aurostibite, pyrrhotite, pyrite, chalcopyrite, gudmundite, berthierite, sphalerite, gold, kermesite, sernamonite, valentinite, tetrahedrite, breithauptite, ullmannite, boulangerite, pääkkönenite, “Ag criddleite” (unidentified mineral) [3, 4, 10].
Gangue	Quartz [4].
Ore composition	Diamond-drill core [1]: 7.50 ppm Au, 0.362 ppm Ag, 1500 ppm As, 366 ppm B, 719 ppm Ba, <0.1 ppm Bi, 14 ppm Co, 42 ppm Cu, 47 ppb Hg, 1 ppm Mo, 60 ppm Ni, 21 ppm Pb, 130 ppm Rb, 113900 ppm S, 8700 ppm Sb, 0.28 ppm Se, 110 ppm Sr, 0.010 ppm Te, 6.9 ppm Th, 5.2 ppm U, 94 ppm V, 3 ppm W, 89 ppm Zn; 67.9% SiO_2, 0.59% TiO_2, 14.4% Al_2O_3, 5.67% Fe_2O_3, 2.09% MgO, 1.58% CaO, 0.51% Na_2O, 3.67% K_2O, 0.12% P_2O_5, 1.93% LOI.
Enriched elements	Au, Ag, As, B, Hg, K, Rb, S, Sb, W(?) [1,3,4,10].
GEOLOGY	
Major host rocks	Plagioclase porphyrite [1,3,4,10]
Minor host rocks	Mica schist, felsic tuffite [10].
Geological setting	A sequence of metapelites and metagreywackes intruded by the intermediate plagioclase and plagioclase-uralite porphyry sills(?) [4].
Intrusives	Plagioclase and plagioclase-uralite porphyries are common in the region and have a calc-alkaline, dacitic to rhyodacitic composition and predate Au-Sb mineralisation [4].

METAMORPHISM

Metamorphic grade	Amphibolite facies [10].
Metamorphic mineral assemblage	Porphyrite: plagioclase - hornblende - quartz - biotite ± cummingtonite [10].

STRUCTURAL SETTING

Closest major shear	NW-trending shear zone extending from Seinäjoki to Peräseinäjoki, >30 km long, 1 km(?) wide [12].
Controlling structure	A 5-15 m wide, oblique shear zone in the host rock; the Au mineralisation is clearly related to this structure which is within the main shear zone [3,4,12].
Veins	Syn- and post-mineralisation quartz veins [10].

ALTERATION

General alteration	Silicification and sericitisation [10].
TIMING	The mineralisation is post 1886±3 Ma which is the zircon U-Pb age for the porphyries in the area [4].
GENETIC MODEL	Orogenic “mesothermal” deposit.
FIGURES	[4]: Regional geology map, several microphotographs of ore minerals [10]: Several outcrop photographs on the host rock.

References

1. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
2. Lestinen, P. 1988. Seinäjoen alueen geokemialliset tutkimukset vuosina 1983-1986. Geological Survey of Finland Rep. S/41/2222/1/1988. 40 p. (in Finnish)
3. Kärkkäinen, N. 1992. Nurmon Kallionsalon kulta-aiheen tutkimukset syksyllä 1991. Geological Survey of Finland Rep. M19/2222/-92/2/10. 9 p. (in Finnish)
4. Appelqvist, H. 1993. Ore mineralogy in the Proterozoic Kalliosalo gold occurrence, western Finland, with preliminary data on an unspecified mineral, Ag3Au3Sb10S10. Geological Survey of Finland, Special Paper 18, 37-44.
5. Julku, T. 1986. Seinäjoen-Nurmon antimonimalmin rikastustutkimus. Helsinki University of Tehcnology, Department of Mining Engineering, unpublished report. 4 p. (in Finnish)
6. Tyni, M. 1983. Lausunto Kalliosalon antimoniesiintymän hyväksikäyttömahdollisuuksista. A letter by Malmikaivos Oy to the Ministry of Trade and Industry. 3 p. (in Finnish)
7. Tyni, M. 1983. Nurmon Kalliosalon antimoni-kultaesiintymän malmiarvio. Myllykoski Oy, unpublished report. 9 p. (in Finnish)
8. Tyni, M. 1989. Saate Malmiosastolle lähetettyyn kirjeeseen koskien sekä Nurmon Kalliosalon antimoniesiintymää että Seinäjoen Pajuluoman tinaesiintymää. Geological Survey of Finland, unpublished report 3 p. (in Finnish)
9. Ahonen, L. & Tuovinen, O. H. 1986. Kalliosalon antimonimalmin bakteeriliuotus. University of Helsinki, Department of Microbiology, unpublished report. 15 p. (in Finnish)
10. Oivanen, P. 1982. Antimonitutkimukset Seinäjoen-Nurmon alueella vuosina 1975-1982. Geological Survey of Finland, unpublished report M19/2222/-82/1/10. 123 p. (in Finnish)
11. Pääkkönen, V. 1966. On the geology and mineralogy of the occurrence of native antimony at Seinäjoki, Finland. Bulletin de la Commission Geologique de Finlande 225. 71 p.
12. Lestinen, P., Kontas, E., Niskavaara, H. & Virtasalo, J. 1991. Till geochemistry of gold, arsenic and antimony in the Senäjoki district, western Finland. Journal of Geochemical Exploration 39, 343-361.

Name	***Marttalanniemi***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Svecofennian **Belt** Southern Ostrobothnia
Map sheet	2222 07 **X coordinate** 6957670 **Y coordinate** 2449500
Municipality	Nurmo
Nearest town, access	10 km SE from Seinäjoki. A sealed road 5 km from the area, a gravel road to the area.
MINING	
Exploration licence no.	4354.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK) (1977-1980, 1987-1991).
Status of development	Prospect.
Best sections	1 m at 14.8 ppm Au [3].
Extent of mineralisation	50-80 m wide and 800 m long [5].
EXPLORATION	
Discovery	As a follow-up of the Sb exploration in the Seinäjoki area, located by percussion drilling into three anomalies in till on 1987 by the GTK [3,4].
Exploration history	GTK (1977-1990) [1,2,3,4,5]: Regional (1981) and localised (1983-) till geochemical survey, till stratigraphy, bedrock mapping, percussion drilling.
Drilling	GTK (1988): percussion drilling: 17 holes, total of 360 m [3].
Elements analysed	As, Au, S, Sb [2].
Primary dispersion	Au, As and Sb anomalies probably envelope the mineralisation [2].
Secondary dispersion	Extensive Au anomalies in the region in till, regional Sb and As anomalies in till are, apparently, unrelated to gold mineralisation [1,5]. Two local, distinct As-Au-Sb anomalies which relate to the Au mineralisations in the bedrock [2].
Exploration geologist(s) in charge	GTK: Niilo Kärkkäinen, Panu Oivanen.
ORE	
Siting of gold	Gold both in tourmaline-quartz veins and in the enveloping, altered host rock [3,4]. "Gold seems to follow As-rich bands [5].
Major opaques	Pyrite, pyrrhotite, arsenopyrite [3,4].
Minor opaques	Galena, sphalerite, gold [5].
Gangue	Quartz, tourmaline, scheelite [3].
Enriched elements	Au, As, B, CO_2, K, Pb, S, W [3,4].
GEOLOGY	
Major host rocks	Dacitic plagioclase porphyry [2,3]
Minor host rocks	Quartz-sericite schist, mica gneiss, greywacke, pegmatites [2,3]
Geological setting	A sequence of metapelites and metagreywackes intruded by the intermediate plagioclase and plagioclase-uralite porphyry sills(?) dominates the geological setting in the area [5].
Intrusives	Pegmatite dikes, several minor (<<1 m wide) and one large (40-100 m wide), whose relationship with the Au mineralisation is unclear [2].
METAMORPHISM	
Metamorphic grade	Mid-amphibolite facies [2,4].
Metamorphic mineral assemblage	Plagioclase - hornblende - quartz - biotite ± cummingtonite [4].
STRUCTURAL SETTING	
Closest major shear	A NW-trending shear zone extending from Seinäjoki to Peräseinäjoki, >30 km long, 1 km(?) wide [2,5].
Controlling structure	A set of 1-15 m wide shear zones which are conform to the dominant foliation in the area and are within the main shear zone [3,5].
Veins	Auriferous tourmaline-quartz veins [3].
ALTERATION	
General alteration	Sulphidation, biotitisation, carbonation, formation of Ca silicates ± tourmaline [2].
Proximal alteration	The Ca-silicate bands possibly reflect the most intense alteration. These comprise: diopside, K feldspar, calcite, epidote, pyrrhotite, and arsenopyrite [2]. There are, also, tourmaline-bearing quartz-sericite rocks in the northern part of the area [2]; these could reflect early epithermal alteration and be unrelated to Au mineralisation.
Intermediate alteration	Intense biotitisation? [2].
Distal alteration	Low-grade biotitisation? [2].

GENETIC MODEL Orogenic “mesothermal” deposit.

References

1. Lestinen, P. 1988. Seinäjoen alueen geokemialliset tutkimukset vuosina 1983-1986. Geological Survey of Finland, unpublished report S/41/2222/1/1988. 40 p. (in Finnish)
2. Kärkkäinen, N. 1989. Kulta-aiheen jatkotutkimukset Poka-kairauksella v. 1988 Nurmon Marttalanniemessä. Geological Survey of Finland, unpublished report. M19/2222/89/1/10. 6 p. (in Finnish)
3. Kärkkäinen, N. 1990. Tutkimustyöselostus Nurmon kunnassa valtausalueella Marttalanniemi, kaiv. rek. n:o 4354, suoritetuista malmitutkimuksista. Geological Survey of Finland, unpublished report. M19/2222/-90/1/10. 5 p. (in Finnish)
4. Oivanen, P. 1982. Antimonitutkimukset Seinäjoen-Nurmon alueella vuosina 1975-1982. Geological Survey of Finland, unpublished report M19/2222/-82/1/10. 123 p. (in Finnish)
5. Lestinen, P., Kontas, E., Niskavaara, H. & Virtasalo, J. 1991. Till geochemistry of gold, arsenic and antimony in the Senäjoki district, western Finland. Journal of Geochemical Exploration 39, 343-361.

Name	***Sudenkylä (Haudankylä)***
GENETIC TYPE	Orogenic 'mesothermal' of Au-Sb subtype.
LOCATION	
Geological domain	Svecofennian **Belt** Southern Ostrobothnia
Map sheet	2222 04 **X coordinate** 6950500 **Y coordinate** 2443710
Municipality	Ilmajoki
Nearest town, access	15 km SW from Seinäjoki. A sealed road 7 km from the mineralisation, a gravel road adjacent to the area.
MINING	
Exploration licence no.	6136/1.
Present holder	Outokumpu Oyj.
Previous holders	Geological Survey of Finland (GTK) (1981-86), Malmikaivos Oy (1986-).
Status of development	Prospect.
Best sections	1 m at 3.5 ppm Au [3].
EXPLORATION	
Discovery	By GTK as a follow-up exploration on an Au anomaly in till detected during regional till geochemical survey [3].
Exploration history	GTK (1981-86) [2,3]: Regional and localised till geochemical survey, till stratigraphy and bedrock mapping. Malmikaivos (1986-) [4]: Bedrock mapping, diamond drilling?
Secondary dispersion	An Au anomaly 600x600 m in size in till; the regional Sb and As anomalies in till are, apparently, unrelated to gold mineralisation [2,3].
Exploration geologist(s) in charge	GTK: Pekka Lestinen; Malmikaivos: Pertti Huopaniemi.
ORE	
Major opaques	Arsenopyrite, pyrrhotite, pyrite(?) [3].
Ore composition	Diamond-drill core [1]: 10.80 ppm Au, 0.70 ppm Ag, 30000 ppm As, 3.0 ppm B, 475 ppm Ba, 19.2 ppm Bi, 999 ppm Co, 632 ppm Cu, 210 ppb Hg, <1 ppm Mo, 775 ppm Ni, 5 ppm Pb, 91 ppm Rb, 104000 ppm S, 2.3 ppm Sb, 7.9 ppm Se, 82 ppm Sr, 5.600 ppm Te, 1.8 ppm Th, 1.6 ppm U, 120 ppm V, <0.5 ppm W, 70 ppm Zn; 46.2% SiO_2, 0.49% TiO_2, 5.56% Al_2O_3, 31.5% Fe_2O_3, 2.66% MgO, 2.28% CaO, 1.60% Na_2O, 2.76% K_2O, 0.039% P_2O_5, 9.00% LOI.
Enriched elements	Au, Ag, As, Bi, Co, Cu, Hg, K, Rb, S, Sb, Se, Te [1].
GEOLOGY	
Major host rocks	Mafic metavolcanic rock [1]; mica gneiss [3].
Geological setting	A sequence of palaeoproterozoic metapelites and metagreywackes intruded by the intermediate plagioclase and plagioclase-uralite porphyry sills(?) [2,3,5].
STRUCTURAL SETTING	
Closest major shear	The mineralisation is between two NW-NNW trending, major shear zones [2,3,5].
GENETIC MODEL	Orogenic "mesothermal" deposit.

References

1. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
2. Lestinen, P. 1988. Seinäjoen alueen geokemialliset tutkimukset vuosina 1983-1986. Geological Survey of Finland, unpublished report S/41/2222/1/1988. 40 p. (in Finnish)
3. Lestinen, P., Kontas, E., Niskavaara, H. & Virtasalo, J. 1991. Till geochemistry of gold, arsenic and antimony in the Senäjoki district, western Finland. Journal of Geochemical Exploration 39, 343-361.
4. Tyni, M. 1983. Lausunto Kalliosalon antimoniesiintymän hyväksikäyttömahdollisuuksista. A letter by Malmikaivos Oy to the Ministry of Trade and Industry. 3 p. (in Finnish)
5. Korsman, K., Koistinen, T., Kohonen, J., Wennerström, M., Ekdahl, E., Honkamo, M., Idman, H. & Pekkala, Y. (eds.) 1997. Suomen kallioperäkartta = Berggrundskarta över Finland = Bedrock map of Finland 1:1 000 000. Geological Survey of Finland.

Name	***Suolasalmenneva***				
GENETIC TYPE	Orogenic ‘mesothermal’.				
LOCATION					
Geological domain	Svecofennian	**Belt**	Southern Ostrobothnia		
Map sheet	2331 03	**X coordinate**	7002470	**Y coordinate**	2508950
Municipality	Alajärvi				
Nearest town, access	15 km SW from Perho. 8 km from a sealed road, 1 km from a gravel road.				
MINING					
Present holder	OPEN FOR ACQUISITION.				
Previous holders	Geological Survey of Finland (GTK).				
Status of development	Prospect.				
EXPLORATION					
Exploration history	GTK (1981-86) [1]: Regional and localised till geochemistry, till stratigraphy and bedrock mapping.				
Secondary dispersion	Extensive Au anomalies in the region in till, but practically no local indications of elevated Au [1].				
Exploration geologist(s) in charge					
	GTK: Jarmo Nikander.				
GEOLOGY					
Major host rocks	Metavolcanic or metasedimentary rocks [1,2].				
Geological setting	A sequence of Palaeoproterozoic metapelites and metagreywackes intruded by the intermediate plagioclase and plagioclase-uralite porphyry sills(?) and the granitoids of the Central Finland Batholith [1,2].				
STRUCTURAL SETTING					
Closest major shear	Western contact of the Central Finland Batholith(?) [2].				
GENETIC MODEL	Orogenic “mesothermal” deposit ?				

References

1. Lestinen, P. 1998 Personal communication 8/10/1998.
2. Korsman, K., Koistinen, T., Kohonen, J., Wennerström, M., Ekdahl, E., Honkamo, M., Idman, H. & Pekkala, Y. (eds.) 1997. Suomen kallioperäkartta = Berggrundskarta över Finland = Bedrock map of Finland 1:1 000 000. Geological Survey of Finland.

Name	***Tervasmäki***
GENETIC TYPE	Orogenic 'mesothermal' of Au-Sb subtype.
LOCATION	
Geological domain	Svecofennian **Belt** Southern Ostrobothnia
Map sheet	2222 08 **X coordinate** 6960050 **Y coordinate** 2445200
Municipality	Nurmo
Nearest town, access	4 km south from Seinäjoki. 3 km from a sealed road, a gravel road across the area.
MINING	
Exploration licence no.	2711/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK) (1975-1982).
Status of development	Prospect.
Best sections	5 m at 1.3 ppm Au and 0.55% Sb [1].
Extent of mineralisation	At surface, 3-23 m wide, 150 m long, open in depth [1].
EXPLORATION	
Discovery	Sb-rich erratic boulders found by amateur prospectors led to discovery of a Sb-mineralisation in outcrop on 1977 by the GTK [1].
Exploration history	GTK (1975-1982) [1,2,3]: Detailed bedrock mapping, trenching, diamond drilling, till stratigraphic and geochemical studies, IP ground survey.
Drilling	GTK (1977-1979) [1]: 10 diamond-drill holes. One or two holes per profile, profiles about 50 m apart.
Geophysical response	A consistent magnetic and electric anomaly about 1 km long, because the wallrock on both sides is a pyrrhotite- and graphite-bearing mica schist.
Secondary dispersion	Extensive Au anomalies in the region in till; the regional Sb and As anomalies in till are, apparently, unrelated to gold mineralisation [3].
Exploration geologist(s) in charge	GTK: Panu Oivanen.
ORE	
Major opaques	Antimony, arsenopyrite [1].
Minor opaques	Loellingite, pyrrhotite, chalcopyrite, gudmundite [1].
Enriched elements	Au, Ag, As, Cu, K, S [1].
GEOLOGY	
Major host rocks	Plagioclase porphyry, mica schist [1].
Geological setting	A sequence of Palaeoproterozoic metapelites and metagreywackes intruded by the intermediate plagioclase and plagioclase-uralite porphyry sills(?)[1,3].
Intrusives	Post-mineralisation(?) pegmatite dikes within the host rock [1].
METAMORPHISM	
Metamorphic grade	Amphibolite facies [1].
Metamorphic mineral assemblage	Plagioclase - hornblende - quartz - biotite ± cummingtonite [1].
STRUCTURAL SETTING	
Closest major shear	A NW-trending shear zone extending from Seinäjoki to Peräseinäjoki, >30 km long, 1 km(?) wide [3].
Controlling structure	A set of minor shear zones which are within the main shear zone [3].
ALTERATION	
General alteration	Sericitisation and silicification in the mica schist [1].
GENETIC MODEL	Orogenic "mesothermal" deposit.
FIGURES	[1]: Local geology map.

References

1. Oivanen, P. 1982. Antimonitutkimukset Seinäjoen-Nurmon alueella vuosina 1975-1982. Geological Survey of Finland, unpublished report M19/2222/-82/1/10. 123 p. (in Finnish)
2. Lestinen, P. 1988. Seinäjoen alueen geokemialliset tutkimukset vuosina 1983-1986. Geological Survey of Finland, unpublished report. S/41/2222/1/1988. 40 p. (in Finnish)
3. Lestinen, P., Kontas, E., Niskavaara, H. & Virtasalo, J. 1991. Till geochemistry of gold, arsenic and antimony in the Senäjoki district, western Finland. Journal of Geochemical Exploration 39, 343-361.

Name	***Timanttimaa***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Southern Ostrobothnia
Map sheet	2222 03 **X coordinate** 6940000 **Y coordinate** 2463000
Municipality	Alavus, Peräseinäjoki
Nearest town, access	10 km E from Peräseinäjoki, about 30 km SSE from Seinäjoki. A sealed road 1 km from the area, a minor gravel road to the area.
MINING	
Exploration licence no.	4186/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Total in-situ gold	500 kg (a rough estimate) [2].
Best sections	1.5 m at 15.5 ppm Au; 3 m and 1.4 m at 1.8 ppm Au [1,2].
Extent of mineralisation	Total thickness about 20 m [1].
EXPLORATION	
Discovery	First indications were outcrop samples provided by amateur prospectors on 1986; this was followed, by the GTK, by the discovery of a till geochemical anomaly and then bedrock mapping and sampling led to the actual discovery [1,2].
Exploration history	GTK (1987-1991) [1,2]: till geochemical survey, bedrock mapping, trenching, electric and magnetic ground survey, diamond drilling.
Drilling	GTK (1987-1991) [1,2]: 9 diamond-drill holes, total 910 m, with 20-70 m distances between the holes.
Elements analysed	As, Au, Cu [1].
Geophysical response	Three of the five IP anomalies in the area indicate the locations of the weakly sulphidised, auriferous shear zones [2].
Secondary dispersion	A combined Au-As-Cu anomaly in till extends, apparently, hundreds of metres from the mineralisation along the trend of glacial transport [2].
Exploration geologist(s) in charge	
	GTK: Niilo Kärkkäinen.
ORE	
Siting of gold	Chiefly free gold in quartz veins [2].
Major opaques	Pyrrhotite, arsenopyrite [2].
Minor opaques	Chalcopyrite, gold [2].
Gangue	Quartz, carbonate, chlorite, scheelite [2].
GEOLOGY	
Major host rocks	Dacitic plagioclase porphyry [1,2].
Minor host rocks	Tonalite [2].
Geological setting	The mineralisation is in the contact zone between the synorogenic Haapaluoma tonalite and the intermediate metavolcanic rock [2]. This “metavolcanic rock” (i.e. the major host rock) may, actually, be a volcanogenic metasedimentary rock.
Intrusives	Synorogenic Haapaluoma tonalite which predates gold mineralisation [2].
STRUCTURAL SETTING	
Structural style	Brittle-ductile [1,2].
Closest major shear	A NE-trending Shear zone adjacent to the area [1].
Controlling structure	A set of silicified, 1-10 m wide shear zones in the host rock [1,2].
Veins	An auriferous quartz vein network [1].
ALTERATION	
General alteration	Formation of biotite, carbonate and chlorite? [1].
GENETIC MODEL	Orogenic “mesothermal” deposit.
FIGURES	[1]: Drilling sections. [2]: Local bedrock map, good drill log figures [2].

References

1. Kärkkäinen, N. 1993. Kultamalminetsintää Peräseinäjoen ja Alavuden Timanttimaalla vuosina 1987-1991. Geological Survey of Finland, unpublished report M19/2223/-92/1/10. 25 p. (in Finnish)
2. Kärkkäinen, N. 1993. Tutkimustyöselostus Alavuden kunnassa (Timanttimaalla) valtausalueella Koukkuluomanmaa 1, kaiv.rek.nro 4186/1 suoritetuista malmitutkimuksista. Geological Survey of Finland, unpublished report. M06/2223/-93/1/10. 5 p. (in Finnish)

Name	***Tulisilmä (Sikakangas)***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Southern Ostrobothnia
Map sheet	2222 07 **X coordinate** 6956500 **Y coordinate** 2444000
Municipality	Seinäjoki
Nearest town, access	5 km south from Seinäjoki. A sealed road at the W margin of the area, a gravel road across the area.
MINING	
Exploration licence no.	4667/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK) (1975-1982, 1989-93).
Status of development	Prospect.
Best sections	5 m at 2 ppm Au, 1 m at 11.8 ppm Au [1,2].
Extent of mineralisation	The NE-striking mineralised area is 200 m x 700 m at the present surface [4].
Lodes	A set of small mineralised lenses with a width of 2-3 m [1,2,4].
EXPLORATION	
Discovery	First indication by gold-rich erratic boulders and outcrop found by an amateur prospector. This led to the discovery of the deposit in outcrop by the GTK on 1989 [1,2].
Exploration history	GTK (1975-1982, 1989-93) [1,2,3,4,5]: Detailed bedrock mapping, trenching, channel sampling from outcrop, diamond drilling, till stratigraphic and geochemical studies, IP ground survey.
Drilling	GTK (1989-93) [1,2]: 19 diamond-drill holes, total 658 m; 1-3 holes per profile, distance between profiles 50 m.
Geophysical response	None by IP, others not tested [1].
Secondary dispersion	Extensive Au anomalies in the region in till, also a local As anomaly enveloping the mineralisation; the regional Sb and As anomalies in till are, apparently, unrelated to gold mineralisation [4].
Exploration geologist(s) in charge	GTK: Panu Oivanen 1975-1982, Niilo Kärkkäinen 1989-1993.
ORE	
Major opaques	Arsenopyrite [1]
Minor opaques	Pyrrhotite, pyrite, gold [1].
Gangue	Quartz, scheelite, tourmaline, calc-silicates [1].
GEOLOGY	
Major host rocks	Plagioclase porphyry [1,2].
Geological setting	A sequence of Palaeoproterozoic metapelites and metagreywackes intruded by the intermediate plagioclase and plagioclase-uralite porphyry sills(?) [1,2,3,4].
Intrusives	Post-mineralisation(?) pegmatite dikes within the host rock, also present in the auriferous shear zone [1].
METAMORPHISM	
Metamorphic grade	Amphibolite facies [1].
Metamorphic mineral assemblage	Plagioclase - hornblende - quartz - biotite ± cummingtonite [3].
STRUCTURAL SETTING	
Structural style	Ductile(-brittle) [1].
Closest major shear	The mineralsiation is between two NNW-trending, major shear zones which can be traced for tens of kilometres [6].
Controlling structure	Subconformable, minor shear zones near the contact between the plagioclase porphyry and the underlying metapelitic rocks [1].
Veins	Quartz-tourmaline veins, 1-10 cm in width; these tend to contain 1-20 ppm Au [1].
ALTERATION	
General alteration	Calc-silicate alteration and weak sulphidation in on about 20 m wide zone containing most of the shear zones [1].
GENETIC MODEL	Orogenic “mesothermal” deposit.

References

1. Kärkkäinen, N. 1993. Tutkimustyöseloste Seinäjoen kaupungin Tulisilmän alueen malmitutkimuksista, koskien valtausaluetta Tulisilmän-mäki 1, kaiv.rek.nro 4667/1. Geological Survey of Finland, unpublished report M06/2222/-93/1/10. 9 p. (in Finnish)
2. Kärkkäinen, N. 1993. Kultamalminetsintää Seinäjoen Tulisilmän alueella vuosina 1989-1990. Geological Survey of Finland, unpublished report M06/2222/-92/1/10. 7 p. (in Finnish)
3. Oivanen, P. 1982. Antimonitutkimukset Seinäjoen-Nurmon alueella vuosina 1975-1982. Geological Survey of Finland, unpublished report M19/2222/-82/1/10. 123 p. (in Finnish)
4. Lestinen, P., Kontas, E., Niskavaara, H. & Virtasalo, J. 1991. Till geochemistry of gold, arsenic and antimony in the Senäjoki district, western Finland. Journal of Geochemical Exploration 39, 343-361.
5. Lestinen, P. 1988. Seinäjoen alueen geokemialliset tutkimukset vuosina 1983-1986. Geological Survey of Finland, unpublished report. S/41/2222/1/1988. 40 p. (in Finnish)
6. Korsman, K., Koistinen, T., Kohonen, J., Wennerström, M., Ekdahl, E., Honkamo, M., Idman, H. & Pekkala, Y. (eds.) 1997. Suomen kallioperäkartta = Berggrundskarta över Finland = Bedrock map of Finland 1:1 000 000. Geological Survey of Finland.

Name	***Ylijoki (Kivenneva)***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Southern Ostrobothnia
Map sheet	2221 12 **X coordinate** 6947730 **Y coordinate** 2451950
Municipality	Nurmo
Nearest town, access	20 km SE From Seinäjoki. 4 km from a sealed road, a gravel road to the area.
MINING	
Exploration licence no.	4673/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK) (1987-1993).
Status of development	Prospect.
Best sections	7 m at 1 ppm Au, 1 m at 6.7 ppm Au [2].
EXPLORATION	
Discovery	On 1987 by the GTK: Au analysed on known arsenopyrite-bearing quartz veins [1,2].
Exploration history	GTK (1981-93) [1,2]: Regional (1981) and localised (1986-) till geochemistry, till stratigraphy, bedrock mapping. Localised studies on 1988-1993 [2]: electric and magnetic ground survey, trenching, diamond drilling.
Drilling	GTK (1988-1990): 11 diamond-drill holes, total 420 m, across the narrow geophysical anomaly [2].
Geophysical response	Good response by combining the IP and the magnetic method [2].
Primary dispersion	There is no obvious correlation between Au and As in local scale [2].
Secondary dispersion	Extensive Au anomalies in the region in till, but practically no local indications of elevated Au [1].
Exploration geologist(s) in charge	
	GTK: Niilo Kärkkäinen.
ORE	
Major opaques	Arsenopyrite [2].
Minor opaques	Pyrrhotite, gold [2].
Gangue	Quartz [2].
GEOLOGY	
Major host rocks	Mica gneiss [2].
Geological setting	The Palaeoproterozoic mica gneiss has been interpreted as a sequence of arkositic greywackes and altered, intermediate, metavolcanic rocks [2].
Intrusives	A granodiorite 500 m to the WSW of the mineralisation and a 200 m wide pegmatite dike at the contact between the mica gneiss and the granodiorite intrusion [2].
STRUCTURAL SETTING	
Closest major shear	A NW-trending shear zone extending from Seinäjoki to Peräseinäjoki, >30 km long, 1 km(?) wide [2].
Veins	A set of auriferous, 0.1-60 m wide, quartz veins [2].
GENETIC MODEL	Orogenic “mesothermal” deposit.
FIGURES	[2]: Outcrop geology map, a combined geophysical anomaly map.

References

1. Kärkkäinen, N. 1992. Kultamalminetsintää Nurmon Ylijoen alueella ja Ämmälänkylässä v. 1988-1990. Geological Survey of. Finland, unpublished reportM19/2221,2222/-92/4/10. 15 p. (in Finnish)

Name	***Hakojärvi***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Southern Savo
Map sheet	3233 05 **X coordinate** 6877500 **Y coordinate** 3555900
Municipality	Rantasalmi
Nearest town, access	About 13 km SW from Rantasalmi, 100 km S from the city of Kuopio. About 7 km from Highway 14; a gravel road to the area.
MINING	
Exploration licence no.	3681/1-2.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	2.5 m at 1 ppm Au and 0.68% As [1].
EXPLORATION	
Discovery	By the GTK: outcrops found on 1984 in a follow-up of the survey of glacial erratic boulders, and till geochemical and IP survey [1].
Exploration history	GTK (1983-1987) [1,3]: Regional and local till geochemistry, detailed bedrock mapping, magnetic, electric and IP ground survey, percussion drilling into till-bedrock interface, diamond drilling.
Drilling	GTK (1984-85): 4 diamond-drill holes, total 503.5 m [1].
Elements analysed	Au, As [1].
Secondary dispersion	Scattered Au-anomalous locations in till around the mineralisation [3].
Exploration geologist(s) in charge	
	GTK: Hannu Makkonen.
ORE	
Major opaques	Arsenopyrite [1].
GEOLOGY	
Major host rocks	Intermed. and felsic volc. metasedimentary rocks [1].
Minor host rocks	Mica gneiss, quartz diorite [1].
Geological setting	The area is characterised by Palaeoproterozoic metavolcanic and metasedimentary rocks which are intruded by synorogenic granitoids, like the Osikonmäki tonalite which has a zircon U-Pb age of 1887±5 Ma [1,2,3]. The synorogenic intrusions are of I- and island-arc type, calc-alkaline, and the general setting a plate tectonic collision, convergent, zone, the Raahe-Ladoga Zone, also known as the Raahe-Bothnian Bay Zone and the Main Sulphide Ore Belt [1,2,3].
METAMORPHISM	
Metamorphic grade	Sillimanite-K feldspar zone [2] (upper-amphibolite facies).
STRUCTURAL SETTING	
Closest major shear	The NW-SE trending, several hundred-km long, transcurrent-dextral Kolkonjärvi Shear Zone, is about 1 km NE from the deposit [1].
TIMING	Post-1887±5 Ma [1,2,3].
GENETIC MODEL	Orogenic “mesothermal” deposit.
FIGURES	[3]: Regional geology map.

References

1. Makkonen, H. 1987. Tutkimustyöselostus Rantasalmen ja Juvan kunnissa valtausalueella Hakojärvi 1 ja 2, kaiv. rek. n:o 3681/1-2 sekä valtausalueella Ratosuo 1 ja 2, kaiv. rek. n:o 3744/1, suoritetuista tutkimuksista. Geological Survey of Finland, unpublished report M06/3233/-87/1/10. 4 p. (in Finnish)
2. Korsman, K., Hölttä, P., Hautala, T. & Wasenius, P. 1984. Metamorphism as a indicator of evolution and structure in the Rantasalmi-Sulkava area, southeaster Finland. Geological Survey of Finland, Bulletin 328. 40 p.
3. Lestinen, P. 1989. Kolkonjärven alueen geokemialliset tutkimukset vuosina 1984-1987. Geological Survey of Finland, unpublished report S/41/3233/1/1989. 42 p. (in Finnish)

Name	***Osikonmäki (Osikko)***				
GENETIC TYPE	Orogenic ‘mesothermal’.				
LOCATION					
Geological domain	Svecofennian	**Belt**	Southern Savo		
Map sheet	3233 09	**X coordinate**	6883100	**Y coordinate**	3563800
Municipality	Rantasalmi				
Nearest town, access	About 4 km SW from Rantasalmi, 100 km S from the city of Kuopio. About 12 km from Highway 14; a gravel road to the area.				
MINING					
Exploration licence no.	4048/1, 4295/1, 4367/1, 4668/1, 6655/1.				
Present holder	Endomines Oy.				
Previous holders	Geological Survey of Finland (GTK) (1986-93), Outokumpu Oyj (1993-95), Ashton Mining (1995-97).				
Status of development	Prospect.				
Resources	2.2 Mt 3.1 ppm Au + 0.09 Mt 4.9 ppm Au, with 0.77% As (at 1 ppm Au cut-off grade) [4,8,11].				
Total in-situ gold	6800 + 440 kg [4,8,11].				
Best sections	25 m at 9.5 ppm Au, 1 m at 68.8 ppm [14,15].				
Extent of mineralisation	The length of the mineralised shear zone is at least 3 km and 2-20 m wide; the Au-mineralised domain is open at both ends [4,8].				
Lodes	Within the shear zone which is pervasively anomalous in Au, there is a set of higher-grade, en echelon lodes [4].				
EXPLORATION					
Discovery	By the GTK on 1986: following a glacial erratic boulder train, at least 20 km long, which was first detected on 1984, discovered by a detailed till-bedrock interface geochemistry and diamond drilling [4,6,11].				
Exploration history	GTK (1985-1993) [2,3,4,9,12,13,14,15,16,17,18,19,20]: Detailed bedrock mapping, trenching, local and regional till stratigraphy and geochemistry, percussion drilling into till-bedrock interface, diamond drilling; detailed studies on ore mineralogy, general geological setting, the type and age of the host rock, fluid inclusions, and benefication and processing of the ore. Outokumpu (1993-95) [14]: pilot plant tests.				
Drilling	GTK (1986-91): 120 diamond-drill holes, total of 16462 m. Drilling is concentrated on the eastern and western portions of the known part of the shear zone, in profiles 25-100 m, mostly 50 m, apart [4,8,14].				
Elements analysed	Al, Ba, Ca, Fe, K, Mg, Mn, Na, P, Rb, Si, Sr, Ti, V, Zr by XRF; S and H2O by Leco; Ag, As, Bi, Cu, Pb, Zn by FAAS and XRF; Au, Bi, Sb, Se, Te by GFAAS; “ore-grade” Au also by Fire assay, and Cu, Mo, Pb Sb and S also by ICP-AES [3,4,16,17].				
Economic evaluations	A preliminary easibility study by Outokumpu (1995?).				
Geophysical response	Good response by IP, no response on radiometric, slingram, gravity or magnetic methods [2,6,8,9].				
Primary dispersion	A geochemical aureole defined by Se, Bi, As, S and Cu is prominent in the hangingwall [4,16]. “Gold is geochemically associated with Bi and Te whereas As-S-Se and Cu-Ag are distinct geochemical associations”; the most useful combination for local exploration is suggested to be Au+Te+Bi [17].				
Secondary dispersion	In till, the Au-As-Te association forms an anomaly that is related to gold mineralisation in the area; in addition, the location of the Osikonmäki mineralisation is indicated by a strong point anomaly [12,15]. Other elements or element combinations do not show anomalies related to gold mineralisation in the area [15].				
Exploration geologist(s) in charge					
	GTK: Olavi Kontoniemi; Endomines: Timo Lindborg.				
ORE					
Siting of gold	Native gold and electrum, with a set of Bi-Se-Te minerals, occur as inclusions and at grain boundaries within and between arsenopyrite, quartz and plagioclase [1,4,16]. Native gold is more abundant towards the centres of early crystallised loellingite-arsenopyrite grains [16].				
Fineness	98-39% Au, 0.1-60.5% Ag, 0.0-0.6% Bi [1,4].				
Major opaques	Pyrrhotite, arsenopyrite, loellingite, chalcopyrite [1,4].				
Minor opaques	Marcasite, sphalerite, galena, ilmenite, rutile, cubanite, covellite, molybdenite, gold, electrum, bismuth, antimony, maldonite, ikunolite, hedleyite, kawazulite, pilsenite [1,4,6,11].				
Gangue	Quartz, scheelite, powellite [1,4,6].				
Ore composition	Diamond-drill core [5]: 7.00 ppm Au, 2.40 ppm Ag, 2600 ppm As, 7.7 ppm B, 549 ppm Ba, 25.3 ppm Bi, 19 ppm Co, 1540 ppm Cu, 15 ppb Hg, <1 ppm Mo, 27 ppm Ni, <2 ppm Pb, 118 ppm Rb, 6300 ppm S, 0.6 ppm Sb, 8.0 ppm Se, 541 ppm Sr, 2.700 ppm Te, 7.9 ppm Th, 4.6 ppm U, 56 ppm V, 1 ppm W, 81 ppm Zn; 65.2% SiO_2, 0.52% TiO_2, 15.2% Al_2O_3, 4.26% Fe_2O_3, 1.63% MgO, 2.88% CaO, 4.35% Na_2O, 3.10% K_2O, 0.18% P_2O_5, 0.85% LOI. Samples with >1 ppm Au (N = 100), median values: 2.05 ppm Au, 0.96 ppm Ag, 5080 ppm As, 6.62 ppm Bi, 391 ppm Cu, 2.9 ppm Mo, 12.5 ppm Pb, 9395 ppm S, 5.7 ppm Sb, 11.9 ppm Se, 0.29 ppm Te [17].				
Enriched elements	Au, Ag, As, Bi, Cu, Mo, Pb, S, Sb, Se, Te [17].				
Ore fluid	Fluid inclusions: aqueous, CO_2-bearing fluids of low to moderate salinity (2-5% NaCl eq.), late aqueousfluids with salinity up to 14% NaCl eq.; however, the post-mineralisation prograde metamorphism hasdestroyed all safe evidence of gold-related fluids in fluid inclusions [4]. On the basis of mineral assemblages, the fluid related to the gold mineralisation had a temperature of about 500°C and contained abundant S and As, smaller amounts of Au, Bi,				

	Se and Te, but practically no halogens [4,16,18]. PT according to fluid inclusions: early, low-salinity fluid, related to D2-D3 at 690°C, 2.0 kbar [18].
Pb isotope data	Whole-rock acid-leach Pb-Pb: 1801±31 Ma [13].
GEOLOGY	
Major host rocks	Tonalite [1,2,3,4,5,6,11,16].
Geological setting	The area is characterised by Palaeoproterozoic metavolcanic and metasedimentary rocks which are intruded by synorogenic granitoids like the Osikonmäki tonalite which has a zircon U-Pb age of 1887±5 Ma [2,4,5,6,7,11,13]. The synorogenic intrusions are of I- and island-arc type, calc-alkaline, and the general setting a plate tectonic collision, convergent, zone, the Raahe-Ladoga Zone, also known as the Raahe-Bothnian Bay Zone and the Main Sulphide Ore Belt [2,3,4,6,11].
Intrusives	The Osikonmäki tonalite intrusion, i.e. the host rock, (1887±5 Ma) clearly predates gold mineralisation, but the mineralisation is, possibly, older than the late-orogenic Putkilahti intrusion complex which has been dated at 1850±7 Ma and is to the east of the mineralisation [2,3,4,8,13]. The mineralisation is cross cut by granite dikes which are associated with late, vertical, faulting and, possibly, with the post-orogenic, ca. 1815 Ma Pirilä granitoids [3,8].
METAMORPHISM	
Metamorphic history	The peak-regional metamorphism, post-dating Au mineralisation, took place at sillimanite-K feldspar zone, during the D2 deformation [2,4]. This was followed by more localised retrograde metamorphism at greenschist-facies conditions. Pb-Pb whole-rock acid-leach data gives an age of 1801±31 Ma and, as there are no intrusions of that age near by and the peak metamorphism is earlier, suggest that this is an age of for retrograde(?) metamorphism [13].
Metamorphic grade	Sillimanite-K feldspar zone, 645°C, 3.4 kbar [4,7,18] (upper-amphibolite facies).
Metamorphic mineral assemblage	Tonalite: plagioclase - quartz - biotite - hornblende ± K feldspar, hornblende, diopside [3,4,16].
STRUCTURAL SETTING	
Structural style	Ductile [2,4,16].
Closest major shear	The NW-SE trending, several hundred-km long, transcurrent-dextral, Kolkonjärvi and Haukivesi Shear Zones are about 3 km SW and NE, respectively, from the deposit [1,2,3,4,8,16]. These are two of the major shear zones of the NW-trending Raahe-Ladoga Zone. In the vicinities of Osikonmäki, the dominant movement along these faults seems to have been dip-slip [2,3,4,16].
Controlling structure	The Osikonmäki Shear Zone (OSZ), a second-order, W-E trending structure which dips to the south at 40-50°; the gold-rich domains within the shear zone plunge to the ESE at about 20° [4,6,11]. The OSZ may be conjugate to the major NW-trending shear zones of the Raahe-Ladoga Zone, and is probably located in the tonalite due to the competent nature of the host rock [4].
Deformation history	Four deformation stages have been detected in the region [2,3,8,11,13]. 1) D1 is detected to the south, in lower-metamorphic grade rocks, but not in the vicinity of the Osikonmäki deposit. 2) The dominant deformational stage in the region, D2, slightly post-dates the synorogenic (1887 Ma) intrusions; it has produced a penetrative schistosity into the rocks of the area. 3) The D3 is related to peak- to slightly post-peak metamorphism, but continued after it, and has a minimum age of 1815 Ma (the age of the late-orogenic intrusions). The major NW-trending shear zones were still active during the D3. 4) The D4 stage is only represented by a crenulation cleavage, and has a maximum age of the post-orogenic granitoids.
Ore fabric	Cataclastic-porphyroclastic-granoblastic and blastomylonitic textures [4,6].
Veins	Concordant, narrow quartz veins in the OSZ [4].
ALTERATION	
General alteration	Probably due to the regional metamorphic overprint, alteration is difficult to detect and, apparently, of small extent [4,16]. The minerals formed during alteration include 1) the confirmed minerals: biotite, quartz, K feldspar, titanite, rutile, tourmaline, sulphides, Bi-Se-Te minerals and gold, and 2) the inferred minerals which are completely replaced by other species during later metamorphism: sericite, albite, chlorite [4,16]. K and S metasomatism are the most prominent alteration features.
Proximal alteration	Plagioclase - quartz - biotite - K feldspar -actinolite - diopside - sulphides [2,3,8].
Intermediate alteration	Not possible to detect, probably due to post-mineralisation modifications.
Distal alteration	Not possible to detect, probably due to post-mineralisation modifications.
TIMING	Later than the intrusion of synorogenic granitoids, i.e. <1887±5 Ma, but earlier than the peak regional metamorphism and the post-orogenic Pirilä-type granites, i.e. >1815±7 Ma [4,13]. The deposit is, possibly, older than the late orogenic Putkilahti intrusion complex which has been dated at 1850±7 Ma [4,13].
GENETIC MODEL	Transport of gold was facilitated by thio- and thioarsenide complexes in fluids of either magmatic and/or metamorphic origin. Mineral parageneses indicate that gold mineralisation took place under amphibolite-facies conditions, but prior to peak regional metamorphism, and that Au was precipitated by the sulphidation of the host rock in strucrutally favourable locations [1,4,11,16]. The element associations, the early As-S-Se, the middle Au-Bi-Te and the late Cu-Ag, are interpreted as representing a temporal continuum of spatially overlapping episodes of precipitation [17].
Post-mineralisation modifications	
	Prograde regional metamorphism at sillimanite-K feldspar zone [2,4,16]. This is followed by retrograde metamorphism at greenschist-facies conditions (<440°C, <2 kbar [7]), near to the late, vertical, brittle faults, which produced chlorite, epidote, actinolite, sericite, calcite, quartz, tourmaline, K feldspar, fluorite and sulphides by the partial replacement of plagioclase and hornblende [4]. Also, minor remobilisation of Au took place by the late,

saline fluids [18].

FIGURES [1,2,3,4,8,9]: Regional and local surface maps, sections, thin section photomicrographs.

References

1. Kontoniemi, O., Johanson, B., Kojonen, K. & Pakkanen, L. 1991 Ore mineralogy of the Osikonmäki gold deposit, Rantasalmi, southeastern Finland. Geological Survey of Finland, Special Paper 12, 81-89.
2. Kontoniemi, O. 1998. An overview of the geology in the Osikonmäki area, Rantasalmi, southeastern Finland: Especially as a promising environment for epigenetic gold mineralization. Geological Survey of Finland, Special Paper 25, 7-18.
3. Kontoniemi, O. 1998. Geology of the Palaeoproterozoic synkinematic Osikonmäki granitoid at Rantasalmi, southeastern Finland. Geological Survey of Finland, Special Paper 25, 19-38.
4. Kontoniemi, O. 1998. Geological setting and characteristics of the Palaeoproterozoic tonalite-hosted Osikonmäki gold deposit, southeastern Finland. Geological Survey of Finland, Special Paper. 25, 39-80.
5. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
6. Kontoniemi, O. & Makkonen, H. 1990. Etelä-Savon kultapotentiaali Rantasalmen tutkimusten valossa. English summary: Southern Savo - a gold potential area in Finland. Vuoriteollisuus 48, 31-34.
7. Korsman, K., Hölttä, P., Hautala, T. & Wasenius, P. 1984. Metamorphism as a indicator of evolution and structure in the Rantasalmi-Sulkava area, southeaster Finland. Geological Survey of Finland, Bulletin 328. 40 p.
8. Kontoniemi, O. 1990. Osikonmäen malmitutkimukset Rantasalmen kunnassa vuosina 1989-1989. Geological Survey of Finland, Unpublished report M19/3233/-91/2/10. 39 p. (in Finnish)
9. Kontoniemi, O. 1994. Osikonmäen kultaesiintymän ympäristön malmitutkimukset Rantasalmella vuosina 1985-1993. Geological Survey of Finland, unpublished report M19/3233/-94/1/10. 20 p. (in Finnish)
10. Kontoniemi, O. 1997. Paleoproterozoic shear zone related gold deposit at Osikonmäki. SE Finland. In: H. Papunen (ed.) Research and Exploration - Where Do They Meet? Proceedings of the Fourth Biennial SGA Meeting, Turku, Finland, 11-13 August 1997. 213-216.
11. Kontoniemi, O. & Ekdahl, E. 1990. Tonalite-hosted early Proterozoic gold deposit at Osikonmäki, southeastern Finland. Bulletin of the Geological Society of Finland 62, 61-70.
12. Lestinen, P. & Kontoniemi, O 1991. Till geochemistry in the surroundings of the Osikonmäki gold deposit, Rantasalmi, southeastern Finland. In: A. J. Lumb, M. J. Brown and C. G. Smith (eds) Exploration and Environment. Abstracts of papers presented at the 9th international conference 'Prospecting in areas of glaciated terrain', Edinburgh, Scotland 2-4th September 1991. British Geological Survey (unpaginated).
13. Kontoniemi, O. & Vaasjoki, M. 1991. Isotopic studies from the Protereozoic Osikonmäki gold prospect at Rantasalmi, southeastern Finland. Geological Survey of Finland, Special Paper 12, 53-57.
14. Kontoniemi, O. 1992. Tutkimustyöselostus Rantasalmen kunnassa valtausalueilla Osikko 1, kaiv.rek.nro 4048/1, Osikko 2, kaiv.rek.nro 4295/1, Osikko 3, kaiv.rek.nro 4367/1 ja Osikko 4, kaiv.rek.nro 4668/1, suoritetuista tutkimuksista.. Geological Survey of Finland, unpublished report M06/3233/-92/1/10. 10 p. (in Finnish)
15. Lestinen, P. 1991. Paltalan alueen geokemialliset Au-tutkimukset vuosina 1988-1990. Geological Survey of Finland, unpublished report S/41/3233/1/1991. 27 p. (in Finnish)
16. Kontoniemi, O. 1998. Geological setting and characteristics of tonalite and shear zone hosted Palaeoproterozoic gold deposit at Osikonmäki, Rantasalmi, southeastern Finland. Synopsis of the PhD thesis. Geological Survey of Finland. 89 p.
17. Bornhorst, T. J., Nurmi, P. A. & Kontoniemi, O. 1998. Geochemistry of gold and associated elements in the Paleoproterozoic Osikonmäki gold deposit, southeastern Finland. Geological Survey of Finland, Special Paper 25, 81-90.
18. Liimatainen, J. 1998. Fluid inclusion data from the Osikonmäki gold deposit, Rantasalmi, southeastern Finland. Geological Survey of Finland, Special Paper 25, 91-99.
19. Leppinen, J. & Kontoniemi, O. 1998. Benefication study of the Osikonmäki refractory-type gold ore at Rantasalmi, southeastern Finland. Geological Survey of Finland, Special Paper 25, 101-110.
20. Wahyudi, T., Bornhorst, T. J. & Nesbitt, C. 1998. A comparative study of cyanide and bromine recovery of gold from a roasted Osikonmäki ore, Finland. Geological Survey of Finland, Special Paper 25, 111-119.

Name	***Pirilä***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Svecofennian **Belt** Southern Savo
Map sheet	3233 06 **X coordinate** 6880960 **Y coordinate** 3555385
Municipality	Rantasalmi
Nearest town, access	About 15 km WSW from Rantasalmi, 100 km S from the city of Kuopio. About 11 km from Highway 14; a gravel road to the area.
MINING	
Exploration licence no.	6655/4.
Present holder	Endomines Oy.
Previous holders	Geological Survey of Finland (GTK), Outokumpu Oy.
Status of development	Prospect.
Resources	0.15 Mt 8 ppm Au, 30 ppm Ag, 3% As [4].
Total in-situ gold	1200 kg [3,4].
Best sections	Several 0.5 m sections with several hundreds of ppm Au [3].
EXPLORATION	
Discovery	1983: a gold-mineralised outcrop detected by the GTK by following glacial erratic boulder trains [2].
Exploration history	GTK (1983-1985): Detailed bedrock mapping, till geochemistry, trenching, percussion drilling into till-bedrock interface, diamond drilling [2,10].
Drilling	GTK (1983-1984): Diamond drilling: 47 holes, total 7540 m [2].
Elements analysed	Au, Ag, As [2,3,4].
Secondary dispersion	A large As anomaly in till, several square-km in size, envelopes the mineralisation and most of the minor Au mineralisations nearby; in local scale, scattered Au-anomalous locations in till around the mineralisation [9].
Exploration geologist(s) in charge	
	GTK: Hannu Makkonen, Endomines: Timo Lindborg.
ORE	
Siting of gold	Gold and electrum grains chiefly occur at the contact between arsenopyrite and loellingite, and as inclusions in these As minerals; some gold is intergrown with quartz and cummingtonite [2].
Fineness	57.1-89.5% Au, 42.9-10.5% Ag [2].
Major opaques	Arsenopyrite, loellingite [2,3].
Minor opaques	Pyrrhotite, pyrite, galena, chalcopyrite, cubanite, gold, electrum, dyscrasite [2,3].
Gangue	Quartz, cummingtonite [2].
Ore composition	Diamond-drill core [1]: 32.00 ppm Au, 15.20 ppm Ag, 31000 ppm As, 9.8 ppm B, 208 ppm Ba, 20.7 ppm Bi, <1 ppm Co, 1890 ppm Cu, 87 ppb Hg, <1 ppm Mo, 38 ppm Ni, 778 ppm Pb, 60 ppm Rb, 26300 ppm S, 5.8 ppm Sb, 7.8 ppm Se, 45 ppm Sr, 0.680 ppm Te, 1.9 ppm Th, 1.8 ppm U, 18 ppm V, 4 ppm W, 432 ppm Zn; 72.1% SiO_2, 0.10% TiO_2, 3.14% Al_2O_3, 14.0% Fe_2O_3, 2.58% MgO, 0.74% CaO, 0.29% Na_2O, 0.93% K_2O, 0.014% P_2O_5, 4.00% LOI.
Enriched elements	Au, Ag, As, Bi, Cu, Hg, S, Sb, Se, Te, Zn [1].
Ore fluid	Weakly saline (<4.0% NaCl eq.) H_2O-CO_2 fluid with up to 10 mole-% CH_4 [6,9]. Homogenisation temperature for the fluid inclusions is 300-325°C [6,9].
Pb isotope data	Whole-rock acid-leach Pb-Pb: 1801±31 Ma [7].
GEOLOGY	
Major host rocks	Intermediate, metavolcanic or volcanogenic metasedim. rock [1,2].
Minor host rocks	Felsic metavolcanic rock or volcanogenic metasedimentary rock [2].
Geological setting	The area is characterised by Palaeoproterozoic metavolcanic and metasedimentary rocks which are intruded by synorogenic granitoids, like the Osikonmäki tonalite which has a zircon U-Pb age of 1887±5 Ma [2,3,7]. The synorogenic intrusions are of I- and island-arc type, calc-alkaline, and the general setting a plate tectonic collision, convergent, zone, the Raahe-Ladoga Zone, also known as the Raahe-Bothnian Bay Zone and the Main Sulphide Ore Belt [2,3,5,7].
Intrusives	Syn-, late- and post-orogenic intrusions in the area, characterised by the Osikonmäki, Putkilahti and Pirilä granitoids, respectively. Gold mineralisation is later than the synorogenic, but older than the post-orogenic intrusions [2,7], took possibly place during the late-orogenic stage [6].
METAMORPHISM	
Metamorphic history	Pb-Pb whole-rock acid-leach data gives an age of 1801±31 Ma - this is, probably the age of retrograde metamorphism [7].
Metamorphic grade	Sillimanite-K feldspar zone at about 3.4 kbar and 645°C [5,6].
Metamorphic mineral assemblage	Felsic rocks: quartz - plagioclase - biotite - K feldspar [8]. Intermediate rocks: quartz - plagioclase - biotite - hornblende [8].

STRUCTURAL SETTING

Closest major shear	The NW-SE trending, several hundred-km long, transcurrent-dextral, Kolkonjärvi Shear Zone is about 500 m NE from the deposit [2].
Controlling structure	The mineralisation is at F2-fold hinges and F2-axial planes [2,3], but formed during the D3(?) [6].
Deformation history	Three-stage deformation with folding during each stage [2]. The major NW-trending shear zones were still active during the D3, at 1.83-1.81 Ga [2,6,8].
Veins	Auriferous uartz ± arsenopyrite veins [2].
ALTERATION	
Proximal alteration	Quartz-cummingtonite zone, thickness up to 65 cm [2].
TIMING	Mineralisation took place during the D3 deformation [6].
GENETIC MODEL	Deposited from a low-salinity, H_2O-CO_2 fluid at 3.4 kbar, 540-670°C; no indications of phase separation [6,9].
Post-mineralisation modifications	
	Retrograde metamorphism at greenschist-facies conditions: <440°C, <2 kbar [5,9].
FIGURES	[2,3,4]: Regional and local surface maps, sections. [10]: Regional geology map.

References

1. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
2. Makkonen, H. & Ekdahl, E. 1985. Pirilän Au-esiintymästä. The gold occurrence at Pirilä. Geologi. 37, 1-4.3. Makkonen, H. & Ekdahl, E. 1988. Petrology and structure of the early Proterozoic Pirilä gold deposit in southeastern Finland. Bulletin of the Geological Society of Finland 60, 55-66.
4. Kontoniemi, O. & Makkonen, H. 1990. Etelä-Savon kultapotentiaali Rantasalmen tutkimusten valossa. English summary: Southern Savo - a gold potential area in Finland. Vuoriteollisuus 48, 31-34.
5. Korsman, K., Hölttä, P., Hautala, T. & Wasenius, P. 1984. Metamorphism as a indicator of evolution and structure in the Rantasalmi-Sulkava area, southeaster Finland. Geological Survey of Finland, Bulletin 3228. 40 p.
6. Poutiainen, M 1993. Fluid inclusion geochemistry of the early Proterozoic Pirilä gold deposit in Rantasalmi, southeastern Finland. Mineralium Deposita 28, 129-135.
7. Kontoniemi, O. & Vaasjoki, M. 1991. Isotopic studies from the Protereozoic Osikonmäki gold prospect at Rantasalmi, southeastern Finland. Geological Survey of Finland, Special Paper 12, 53-57.
8. Kontoniemi, O. 1998. An overview of the geology in the Osikonmäki area, Rantasalmi, southeastern Finland: Especially as a promising environment for epigenetic gold mineralization. Geological Survey of Finland, Special Paper 25, 7-18.
9. Poutiainen, M. 1992. Studies of fluid inclusions in metamorphic rocks and sulphide (-gold) deposits from the Svecofennian and Archean domains in Finland. PhD thesis, Department of Geology, University of Helsinki. 96 p.
11. Lestinen, P. 1989. Kolkonjärven alueen geokemialliset tutkimukset vuosina 1984-1987. Geological Survey of Finland, unpublished report S/41/3233/1/1989. 42 p. (in Finnish)

Name	***Pirilä II***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Svecofennian **Belt** Southern Savo
Map sheet	3233 06 **X coordinate** 6882000 **Y coordinate** 3554780
Municipality	Rantasalmi
Nearest town, access	About 15 km WSW from Rantasalmi, 100 km S from the city of Kuopio. About 12 km from Highway 14; a gravel road to the area.
MINING	
Exploration licence no.	3682/1-2.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK) (1984-1986).
Status of development	Prospect.
Resources	0.03 Mt with 2.7 ppm Au [4].
Total in-situ gold	81 kg [4].
Best sections	2 m at 3.4 ppm Au, 1.5 m at 2.7 ppm Au, 1.1 m 2.5 ppm Au [1,4].
Lodes	One lode with a plunge of 40° and average thickness of 1 m [4].
EXPLORATION	
Discovery	By GTK on 1984: gold-mineralised outcrop detected by following glacial erratic boulder trains and till geochemistry [4].
Exploration history	GTK (1984-1986): Detailed bedrock mapping, till geochemistry, trenching, percussion drilling into till-bedrock interface [4].
Elements analysed	Au, Ag, As [4].
Geophysical response	Good response with IP [4].
Exploration geologist(s) in charge	GTK: Hannu Makkonen.
ORE	
Major opaques	Arsenopyrite, loellingite, pyrite [4].
Minor opaques	Galena, chalcopyrite, sphalerite, gold, electrum [4].
Gangue	Quartz [4].
Ore composition	Bulk-ore sample [1]: 3.10 ppm Au, 1.90 ppm Ag, 18000 ppm As, 17 ppm B, 1450 ppm Ba, 0.4 ppm Bi, 10 ppm Co, 49 ppm Cu, 19 ppb Hg, <1 ppm Mo, 51 ppm Ni, 22 ppm Pb, 93 ppm Rb, 14100 ppm S, 49 ppm Sb, 0.46 ppm Se, 232 ppm Sr, 0.020 ppm Te, 8.0 ppm Th, 4.5 ppm U, 120 ppm V, 18 ppm W, 158 ppm Zn; 64.8% SiO_2, 0.63% TiO_2, 15.2% Al_2O_3, 6.77% Fe_2O_3, 2.56% MgO, 0.76% CaO, 2.01% Na_2O, 3.57% K_2O, 0.15% P_2O_5, 2.70% LOI.
Enriched elements	Au, Ag, As, Ba, K, Rb, S, Sb, W [1].
GEOLOGY	
Major host rocks	Intermediate metavolcanic rock [3,4].
Geological setting	The mineralisation is in a sequence of Palaeoproterozoic metavolcanic and metasedimentary rocks which are intruded by synorogenic granitoids [2,3]. The synorogenic intrusions are of I- and island-arc type, calc-alkaline, and the general setting a plate tectonic collision, convergent, zone, the Raahe-Ladoga Zone, also known as the Raahe-Bothnian Bay Zone and the Main Sulphide Ore Belt [2,3].
Intrusives	Syn-, late- and post-orogenic intrusions in the area, characterised by the Osikonmäki, Putkilahti and Pirilä granitoids, respectively. Gold mineralisation is later than the synorogenic, but older than the post-orogenic intrusions, possibly older than the late-orogenic ones, as well [2,3].
METAMORPHISM	
Metamorphic history	Pb-Pb whole-rock acid-leach data gives an age of 1801±31 Ma at the Pirilä deposit nearby - this is, probably the age of retrograde metamorphism [5].
Metamorphic grade	Sillimanite-K feldspar zone [3,4] (upper-amphibolite facies).
STRUCTURAL SETTING	
Closest major shear	The NW-SE trending, several hundred-km long, transcurrent-dextral Kolkonjärvi Shear Zone, about 500 m NE from the deposit [3].
Deformation history	Three-stage deformation with folding during each stage [2]. The major NW-trending shear zones were still active during the D3, at 1.83-1.81 Ga [2].
Veins	Quartz ± arsenopyrite veins [2].
GENETIC MODEL	An orogenic "mesothermal" deposit.

References

1. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
2. Korsman, K., Hölttä, P., Hautala, T. & Wasenius, P. 1984. Metamorphism as a indicator of evolution and structure in the Rantasalmi-Sulkava area, southeaster Finland. Geological Survey of Finland, Bulletin 3228. 40 p.

3. Makkonen, H. & Ekdahl, E. 1988. Petrology and structure of the early Proterozoic Pirilä gold deposit in southeastern Finland. Bulletin of the Geological Society of Finland 60, 55-66.
4. Makkonen, H. 1987. Tutkimustyöselostus Rantasalmen kunnassa valtausalueilla Pirilä 2 ja 3, kaiv. rek. n:o 3682/1-2, suoritetuista tutkimuksista. Geological Survey of Finland, unpublished report M06/3233/-87/1/10. 5 p. (in Finnish)
5. Kontoniemi, O. & Vaasjoki, M. 1991. Isotopic studies from the Protereozoic Osikonmäki gold prospect at Rantasalmi, southeastern Finland. Geological Survey of Finland, Special Paper 12, 53-57.

Name	***Haveri***
GENETIC TYPE	Orogenic 'mesothermal' or synvolcanic (VMS-type).
LOCATION	
Geological domain	Svecofennian **Belt** Tampere Schist Belt
Map sheet	2124 02 **X coordinate** 6845400 **Y coordinate** 2460200
Municipality	Viljakkala
Nearest town, access	1 km NW from Viljakkala, 35 km NW from Tampere. A sealed road crosses the area.
MINING	
Exploration licence no.	2528, 2574, 2668, 3058, 6130/1.
Mining concession no.	486/2a.
Present holder	Baltic Minerals Finland Oy (Glenmore Highlands & SES Finland JV).
Previous holders	Vuokseniska Oy (1935-1960), Outokumpu Oy (1976-1986).
Status of development	Prospect.
When mined	18th century, 1942-1962 by Vuoksenniska [9].
Total production	4.2 t Au, 6000 t Cu of 1.5 Mt of ore [9]
Best sections	Peltosaari: 3.6 m at 8.6 ppm Au, 16 m at 7.1 ppm Au, 12.6 m at 6.35 ppm Au and 0.21% Cu, 11.4 m at 6.2 ppm Au and 0.2% Cu, 9 m at 6 ppm Au, 58 m at 3 ppm and 0.25-0.30% Cu [1,11]. Haveri Mine: 4.7 m at 7.2 ppm Au, 15 m at 4.8 ppm Au, 99 m at 2 ppm Au, 10 m at 2 ppm Au [1,11]. Tombstone Zone: 3 m at 37.8 ppm Au and 0.93% Cu [1].
Extent of mineralisation	Peltosaari (interpreted): 700 m long, 50 m wide, plunge 50° to the NW [1].
Lodes	Four areas of potential for developing in an area of 0.7 x 1.4 km: Haveri Mine area, Peltosaari Zone, Haveri North, and Tombstone Zone [1,11]. Earlier reports [3,4] suggest that, within the mineralised areas of the Haveri Mine and Peltosaari Zone, it is difficult to estimate the extent of the domains of high-grade gold mineralisation. However, no structural study is available.
EXPLORATION	
Discovery	Deposit has been known since the 18th century when there were small-scale open pit operations for iron production [8].
Exploration history	Vuoksenniska (1930's-1960's) [2,3,4]: Diamond drilling, geological mapping, geophysical ground surveys. Outokumpu (1976-77) [2,3,4]: Geological mapping, airborne and ground magnetic, electromagnetic and gravity surveys, and diamond and percussion drilling in the Peltosaari area. A study of the genesis of the deposit, includes whole-rock geochemical analyses, S-isotope studies, evaluation of the geological evolution and regional metamorphism of the area [3]. Outokumpu (1980-1986) [5]: evaluation of the amount of Au and Co in the tailings of the mine: auger drilling, geochemical analyses, pilot enrichment and leaching of the tailings material. Glenmore & SES J.V. (= Baltic Minerals Finland Oy; 1996-) [1,7,11]: Diamond and percussion drilling, trenching, channel sampling, ground and airborne electromagnetic, self-potential and magnetic survey, analysis of more than 5000 pulp samples of old diamond drill cores, remapping of the area, till geochemistry (50 m sample grid); undergoing resource estimation, dewatering the old mine; underground drilling planned for.
Drilling	Vuoksenniska (1930's-1960's) [2,3,4]: several diamond-drill holes. Outokumpu (1976-77) [2,3,4]: diamond and percussion drilling in the Peltosaari area; diamond drilling of 12 holes, total 1671 m, in 8 profiles. Glenmore & SES (1996-) [1,7,11]: in the Tombstone Zone, Haveri Mine area and the Peltosaari Zone, 5200 m diamond drilling concentrated on the latter two; drilling in profiles of 30-40 m at Peltosaari during 1996 to early 1997. During late 1997, 22 diamond-drill holes, 2519 m, at Peltosaari and 2 diamond-drill holes, 206 m, at the Mine Zone.
Elements analysed	Al, Ag, Au, As, Ba, Ca, Co, Cr, Fe, H_2O, Mg, Mn, Na, P, Pb, Rb, S, Si, Sr, Ti, Zn, Zr [3]; As, Au, Co, Cu, Fe, Pb, S, Zn [5]. Wall rocks only: Al, Ba, Ca, Cl, Cr, Fe, Mg, Mn, Na, P, Rb, REE, S, Si, Sr, Ti, V, Zn, Zr [6]. Au by fire assay, Cu by ICP-AES [7,11].
Economic evaluations	Glenmore & SES: Feasibility study under way1998-1999.
Geophysical response	Magnetic, electric (slingram) and gravimetric anomaly in the area of mineralisation, but the high-grade gold mineralisation cannot be detected by geophysical methods [2]. The mineralised zones have a good response on electric methods only [4].
Primary dispersion	Gain in Ba, K, Rb, Ca, loss in Na in the volcanic breccia, extent of the anomaly not known [6].
Exploration geologist(s) in charge	Outokumpu: E. Pehkonen; Glenmore: William Karvinen, Toby Strauss.
ORE	
Siting of gold	Native gold occurs mainly along grain boundaries of Co and As minerals and as very fine-grained inclusions in cobaltite and larger inclusions in silicates [3]. Gold appears to occur in two settings, high grade (more than 10 ppm) in siliceous zones of a few metres wide in altered felsic volcanic rocks where Cu content is low (<0.02%), and low grade (2-10 ppm) with sulphides which form irregular masses, stringers and groups of semi-massive to massive lenses along with Cu sulphides with an average Cu content of 0.2-0.35% [1].

Fineness	83.86% Au, 16.84% Ag [3].
Major opaques	Pyrrhotite, magnetite, chalcopyrite, pyrite [3,7]
Minor opaques	Sphalerite, cobaltite, gersdorffite, arsenopyrite, molybdenite, cubanite, vallerite, hessite, tellorobismuthite, ilmenite, glaucodote, gold [3,7,9].
Gangue	Quartz, hornblende, biotite, plagioclase, epidote, scheelite, titanite [3,7].
Enriched elements	Au, Cu + As, Ba, Ca, Rb, K, S, Zn; depleted: Na [2,3,6].
Ore fluid	Fluid for the Cu mineralisation is from sea water [3].
Stable isotope data	$\delta^{34}S$ is fluctuating (-0.5 - +8.7‰), but averages at +6.3‰ (pyrrhotite in breccia ore in mafic metalava) [3].
Pb isotope data	Pb composition is of mantle type [8]. The whole-rock Pb gives an age of 1990±25 Ma [8], which seems, possibly, 70 Ma too early for the general evolution of the Tampere Schist Belt [6].
GEOLOGY	
Major host rocks	Felsic(?) metavolcanic rocks [2,3,5]; tholeiitic metabasalts [10].
Minor host rocks	Mafic metavolcanic rocks [2].
Geological setting	The mineralisation is in the westernmost part of the Tampere Schist Belt; the rocks have an approximate age of 1.9 Ga and were formed in extensional setting, probably in a marginal, back-arc(?), basin [6]. The local geology consists of a sequence of submarine, massive, pillowed and brecciated, low-K to medium-K tholeiitic mafic lavas, felsic(?) pyroclastic deposits, mica and black schists, 10-40 cm thick inter-flow cherts(?) and marbles [3,6]. All of these are intruded by sub-volcanic felsic to intermediate porphyries in a volcanic vent environment and by granitoid bodies [2,3,5]. Local stratigraphy [4,7] upwards from the lowermost unit: mafic metalavas, lava breccia with Au-Cu mineralisation, tuffs and tuffites (also these are pyrrhotite-bearing and related to geophysical anomalies, but do not contain any significant volumes of Cu or Au), metaturbidites.
Intrusives	Cross-cutting porphyry units which apparently post-date, but seem to have locally remobilised the Cu-Au mineralisation [3,7]. The granitoids most probably post-date the mineralisation.
METAMORPHISM	
Metamorphic grade	Lower-amphibolite facies, T = 550°C, p = 2.5 kbar [3,7].
Metamorphic mineral assemblage	Mafic metavolcanic rocks: hornblende - plagioclase - epidote - quartz - titanite [3]. Metapelites: quartz - biotite - plagioclase - cordierite and quartz - biotite - plagioclase - staurolite [3]. Marble: carbonate - quartz - tremolite - grossular garnet [3].
STRUCTURAL SETTING	
Structural style	Brittle [7].
Closest major shear	[6]: Two major, post mineralisation(?) fault zones occur within 5 km of the mineralisation.
Controlling structure	F1/F2 fold interference pattern [10]. Au mineralisation has a clear structural control [11].
Deformation history	[6]: The area is on the northern limb of a major F1 syncline. Porphyroblasts have grown before the end of D1. To the west of the Haveri area, migmatitisation possibly took place during D1 and between D1 and D2. D3 deformation is related with retrograde metamorphism and minor synforms and antiforms.
Veins	Earlier, chlorite-amphibole(?)- and sulphide-filled veins and later, quartz- and epidote ± quartz-filled veins; minor volumes of remobilised sulphides occur in the later veins [7]
ALTERATION	
General alteration	Biotitisation and intense Mg-Fe metasomatism, especially in the felsic-intermediate units, which have got an mafic composition due to alteration [2,7]. In addition, bleached haloes up to 3 cm wide are common around chlorite-amphibole(?) veins reflecting the earliest stages of alteration which, probably, took place under synvolcanic, submarine, conditions [3,7].
TIMING	Synvolcanic, submarine, pre-metamorphic, base-metal mineralisation [3]. Whole-rock Pb gives an age of 1990±25 Ma [8], which seems, possibly, 70 Ma too early for the general evolution of the Tampere schist belt [6]. In any case, it is entirely uncler if the Au mineralisation is early or late.
GENETIC MODEL	The present view [7] is, that there is a synvolcanic Cu±Au mineralisation overprinted by an epigenetic Au mineralisation. "The gold-copper mineralisation is formed in an island arc, volcanic, submarine, massive-sulphide environment, resembling the Horne deposit in Noranda, Quebec, and, in general, Cyprus-type ores" [1,3]. Sulphur isotopes suggest origin for S from sea water [3]. An alternative geotectonic setting [6]: the mineralisation is formed in an extensional setting, probably in a marginal basin. An alternative scenario [10]: The Au-Cu deposit is in a F1/F2 fold interference pattern in the western core of the large fold; the ore-forming elements concentrated into the F1 closure during D1, this was followed by weak remobilisation during D2.
Post-mineralisation modifications	Regional metamorphic recrystallisation, chloritisation and minor remobilisation of sulphides in cross-cutting rock units and veins.
FIGURES	[3]: Regional and local geological maps, geochemical plots, thin section photomicrographs. [4]: Geological map, drilling profiles.

References

1. Glenmore Highlands Inc. 1997. Glenmore Highlands Inc. announces major progress at Haveri. Press release 8/8/1997.
2. Karvinen, W. O. 1997. The Haveri copper-gold mine property, southern Finland. Geological Survey of Finland, Guide 44, 20-22.
3. Mäkelä, K. 1980. Geochemistry and origin of Haveri and Kiipu, Proterozoic strata-bound volcanogenic gold-copper and zinc mineralizations from southwestern Finland. Geological Survey of Finland, Bulletin 310. 79 p.
4. Pehkonen, E. 1979. Kaivoslain 19§:n mukainen tutkimustyöselostus "Haveri 1-4". Outokumpu Oy, unpublished report. 3 p. (in Finnish)
5. Kokkola, M. 1986. Kaivoslain 19§:n mukainen tutkimustyöselostus Viljakkala, Haveri, kaivosrekisterinumero 3058. Outokumpu Oy,

unpublished report. 3 p. (in Finnish)
6. Kähkönen, Y. & Nironen, M. 1994. Supracrustal rocks around the Paleoproterozoic Haveri Au-Cu deposit, southern Finland: evolution from a spreading center to a volcanic arc environment. Geological Survey of Finland, Special Paper 19, 141-159.
7. Strauss, T. 1997. Personal communication 31/10/1997.
8. Vaasjoki, M. & Huhma, H. 1987. Lead isotopic results from metabasalts of the Haveri Formation, southern Finland: an indication of early Proterozoic mantle derivation. Terra Cognita 7, 159.
9. Isokangas, P. 1978. Finland. In: S.H.U. Bowie, A. Kvalheim & H.W. Haslam (eds) Mineral Deposits of Europe, Vol. I: Northwest Europe. Dorking: Insitute of Mining and Metallurgy, Mineralogical Society, 39-92.
10. Nironen, M. 1994 Structural control and (re)mobilization of the extinct Haveri Au-Cu deposit, southern Finland. Bulletin of the Geological Society of Finland. 66, 39-44.
11. Glenmore Highlands Inc. 1998. Glenmore Highlands Inc. announces update on Haveri project. Press release 23/2/1998.

Name	***Hopeavuori***				
GENETIC TYPE	Orogenic ‘mesothermal’.				
LOCATION					
Geological domain	Svecofennian	**Belt**	Vammala Migmatite Zone		
Map sheet	2114 10	**X coordinate**	6778880	**Y coordinate**	2497940
Municipality	Valkeakoski				
Nearest town, access	7 km SSE from Toijala, 45 km S from Tampere city centre. A gravel road to the area, 3 km to a sealed road.				
MINING					
Exploration licence no.	5085/1-2, 6702/1.				
Present holder	Terra Mining (1997-).				
Previous holders	Geological Survey of Finland (GTK) (1992-1995).				
Status of development	Prospect.				
Best sections	10.5 m at 20 ppm Au or 17.5 m at 13.1 ppm Au; 4.2 m at 14 ppm Au, 4.4 m at 31.7 ppm Au [2].				
Extent of mineralisation	Apparently irregular shape(s): difficult to estimate [2].				
EXPLORATION					
Discovery	Arsenopyrite-rich erratic boulders found by an amateur prospector 1991 led GTK to the discovery in outcrop after bedrock mapping [2].				
Exploration history	GTK (1992-1994) [1,2]: Detailed bedrock mapping, thin section investigations, magnetic, IP and gravimetric ground survey, till geochemistry, diamond drilling. Terra Mining (1997-) [3]: till geochemical survey.				
Drilling	GTK [1,2]: 31 diamond-drill holes, total 2096 m.				
Elements analysed	As (GFAAS), Au (GFAAS), S (Leco) [2].				
Geophysical response	Magnetic, IP and gravimetric anomalies in the region could not be connected to the Au mineralisation [2].				
Secondary dispersion	Local anomalous Au and As values, up to 1.6 ppm and about 5000 ppm, respectively, in till [2].				
Exploration geologist(s) in charge					
	GTK: Boris Lindmark. Terra Mining: Tapio Lehto.				
ORE					
Major opaques	Arsenopyrite [2].				
GEOLOGY					
Major host rocks	Intermed. metavolcanic rock and granodiorite [2].				
Minor host rocks	Mafic metavolcanic rock, felsic porphyry [2].				
Geological setting	The deposit is in the southern part of 40-50 km wide migmatite belt between Tampere and Hämeenlinna; the rocks in the area form a sequence of mica schists and metavolcanic rocks which are intruded by quartz porphyry dikes and granodiorites [2].				
Intrusives	Synorogenic granodiorite and late(?)-orogenic, cross-cutting quartz porphyry: both predate gold mineralisation [2].				
METAMORPHISM					
Metamorphic grade	Amphibolite facies [2].				
STRUCTURAL SETTING					
Controlling structure	Cross-cutting shear zones, highest Au values where the shear zones are in intermediate metavolcanic rock near the contact between the metavolcanic rock and granodiorite [2].				
Veins	As- and Au-bearing quartz veins [2].				
GENETIC MODEL	Orogenic “mesothermal” deposit.				
FIGURES	[2]: Local geology map, several drilled sections with Au values and rock types.				

References

1. Lindmark, B. 1995. Tutkimustyöselostus Valkeakosken kaupungin valtausalueella Hopeavuori 2 (kaivosrekisterinro 5085/2), suoritetuista kultatutkimuksista vuosina 1992-1994. Geological Survey of Finland, unpublished report M06/2114/-95/1/10. 11 p. (in Finnish)
2. Lindmark, B. & Koistinen, E. 1996. Tutkimustyöselostus Valkeakosken kaupungin valtausalueella Hopeavuori 1 (kaivosrekisterinro 5085/1) suoritetuista kultatutkimuksista vuosina 1992-1994. Geological Survey of Finland, unpublished report. M06/2114/-96/1/10. 15 p. (in Finnish)
3. Lehto, T. 1998. Personal communication 14/10/1998.

Name	***Isovesi***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Tampere Schist Belt
Map sheet	2122 05 **X coordinate** 6843050 **Y coordinate** 2431000
Municipality	Suodenniemi
Nearest town, access	22 km SE from Kankaanpää, 50 km WNW from Tampere. A sealed road 500 m from the area.
MINING	
Exploration licence no.	3855/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oy (1967-1991).
Status of development	Prospect.
Best sections	3.7 m at 5.3 ppm Au, 2 m at 4.8 ppm Au [2,3].
Extent of mineralisation	Irregular shape, apparently difficult to estimate the extent of the mineralised blocks [3].
EXPLORATION	
Discovery	An erratic, Au- and As-rich boulder found by an amateur prospector on 1957; later, on 1967, this led Outokumpu to discover the deposit after a detailed bedrock mapping [1].
Exploration history	Outokumpu (1967-1991) [2]: bedrock mapping, magnetic and electric ground surveys, channel sampling and diamond drilling.
Drilling	Outokumpu (1967-1991): 6 diamond-drill holes, total 506 m [2].
Elements analysed	By XRF: major elements, Ba, Bi, Cr, Cu, Mo, Nb, Ni, Pb, Rb, S, Se, Sn, Sr, Tl, Y, W, Zn, Zr; by NAA: As, Au, Ce, Co, Cr, Cs, Eu, Hf, La, Lu, Nd, Sb, Sc, Sm, Ta, Tb, Th, U, W, Yb; by ICP: Ag, Ba, Be, Co, Cr, Cu, Fe, La, Li, Mo, Na, Ni, Pb, Rb, Sc, Sr, V, Y, Zn, Zr [2].
Geophysical response	Positive anomalies on both magnetic and electromagnetic methods [2].
Primary dispersion	Strongest correlation with Au is shown by Ag, Bi and Te [2].
Exploration geologist(s) in charge	
	Outokumpu: Olli-Pekka Isomäki.
ORE	
Siting of gold	Associated both with silicates and arsenopyrite, both in fractures and as inclusions, and commonly with native bismuth, grain size is 1-60 microns [2,3].
Major opaques	Arsenopyrite [2,3].
Minor opaques	Pyrrhotite, pyrite, chalcopyrite, haematite, native bismuth, loellingite, sphalerite, gold, tellorobismuth, galena [2,3].
Gangue	Quartz, epidote, hedenbergite, hornblende, titanite, grunerite, scheelite, graphite [2,3].
Ore composition	Diamond-drill core [1]: 1.42 ppm Au, 0.472 ppm Ag, 7200 ppm As, 15.8 ppm B, 205 ppm Ba, 13.3 ppm Bi, 7 ppm Co, 645 ppm Cu, 13 ppb Hg, <1 ppm Mo, 22 ppm Ni, <2 ppm Pb, 69 ppm Rb, 32000 ppm S, 3.5 ppm Sb, 27 ppm Se, 416 ppm Sr, 4.300 ppm Te, 2.1 ppm Th, 1.3 ppm U, 130 ppm V, 0.5 ppm W, 83 ppm Zn; 46.6% SiO_2, 0.60% TiO_2, 14.2% Al_2O_3, 15.9% Fe_2O_3, 2.72% MgO, 13.1% CaO, 1.83% Na_2O, 1.45% K_2O, 0.18% P_2O_5, 2.93% LOI.
	Diamond-drill core, high-grade mineralisation [2]: 19.0 ppm Au, 1.5 ppm Ag, 12000 ppm As, 33 ppm Ba, 7.3 ppm Be, 352 ppm Bi, 28 ppm Co, 23 ppm Cr, 832 ppm Cu, 15 ppm Li, 36 ppm Ni, 34 ppm Pb, 49800 ppm S, 11.0 ppm Sb, 6.0 ppm Sc, 27.8 ppm Se, 11 ppm Sn, 320 ppm Sr, 46.10 ppm Te, <1.2 ppm Th, <2 ppm U, 446 ppm V, <8 ppm W, 11.7 ppm Y, 30 ppm Zn, 36.5 ppm Zr; 40.83% SiO_2, 0.32% TiO_2, 10.09% Al_2O_3, 11.25% Fe_2O_3, 16.77% MgO, 14.05% CaO, 1.15% Na_2O, 0.06% K_2O, 0.15% P_2O_5.
Enriched elements	Au, Ag, As, Bi, Sb, Se, Te [1,2].
GEOLOGY	
Major host rocks	Intermediate volcanogenic metasedimentary rock [4].
Geological setting	The geotectonic environment is arc-accretionary [2]. The deposit is in the westernmost part of the Tampere Schist Belt, in Kankaanpää Schist Belt, in a metavolcanic-metasedimentary sequence surrounded by granitoid intrusions [2,3].
Intrusives	Synorogenic granitoid intrusions envelop the host rock sequence [2,3].
METAMORPHISM	
Metamorphic grade	Amphibolite facies [2,3].
Metamorphic mineral assemblage	Host rock: plagioclase-hornblende ± epidote, K feldspar, titanite, calcite [2,3].
STRUCTURAL SETTING	
Controlling structure	A NW-trending shear zone [3].
Veins	Quartz-epidote-haematite veins [3].
ALTERATION	
General alteration	“Skarnification”: formation of epidote, hedenbergite and carbonate (calcite?) [2,3].

Proximal alteration Epidote-hedenbergite-calcite [2,3].

TIMING Pre-peak metamorphic, as loellingite partially replaces arsenopyrite [3].

GENETIC MODEL Sequence of mineralisation [2]: I) pyrrhotite-arsenopyrite-loellingite: "intense fracturing after the main stage of skarn reactions", II) pyrrhotite-arsenopyrite-pyrite-chalcopyrite-sphalerite-titanite: "moderate silicic replacement reactions in fractures", and III) pyrite-pyrrhotite-arsenopyrite-sphalerite-electrum-gold-pilsenite-galena-haematite: "late Au-Bi mineralisation stage with minor replacement reactions".

Post-mineralisation modifications

Retrograde sericitisation, epidotisation, chloritisation and carbonation, which are most common near shear zones [3].

FIGURES [2]: Regional geology map, photomicrographs on ore minerals.
[3]: Regional geology map.

References

1. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991 Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
2. Luukkonen, A. 1994. Main geochemical features, metallogeny and hydrothermal alteration phenomena of certain gold and gold-tungsten prospects in southern Finland. Geological Survey of Finland, Bulletin 377. 153 p.
3. Luukkonen, A., Grönholm, P. & Hannila, T. 1992. Eräiden Etelä-Suomen kulta- ja sen seuralaismetalliesiintymien geologiset pääpiirteet. Summary: Main geological features of certain gold and tungsten-tin-gold prospects in southern Finland. Geological Survey of Finland, Report of Investigation 113. 90 p.
4. Yli-Kyyny, K. 1998. Personal communication 26/02/98.

Name	***Jokisivu (Kujankallio)***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Svecofennian **Belt** Vammala Migmatite Zone
Map sheet	2112 01 **X coordinate** 6779500 **Y coordinate** 2425800
Municipality	Huittinen
Nearest town, access	7 km SSW from Huittinen, 85 km NE from Turku. 3 km to a sealed road (Highway 41), a gravel road to the area.
MINING	
Exploration licence no.	5320/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oyj (1985-).
Status of development	Prospect.
Resources	>0.017 Mt 11.3 ppm Au [2].
Total in-situ gold	190 kg [2].
Lodes	Possibly, a set of pipe-formed small lodes [3].
EXPLORATION	
Discovery	First indication was a boulder sample found by an amateur prospector in 1964; no further investigations at that time. Another Au-rich boulder sample was found 1982, this led to further investigations by Outokumpu and discovery of the deposit on 1985 [2,3].
Exploration history	Outokumpu (1985-) [2,3]: Boulder sampling, geochemical till investigations, bedrock mapping, IP and magnetic ground surveys, channel sampling and diamond drilling.
Drilling	Outokumpu (1985-): 64 diamond-drill holes, total 2592 m [3].
Elements analysed	By XRF: major elements, Ba, Bi, Cr, Cu, Mo, Nb, Ni, Pb, Rb, S, Se, Sn, Sr, Tl, Y, W, Zn, Zr; by NAA: As, Au, Ce, Co, Cr, Cs, Eu, Hf, La, Lu, Nd, Sb, Sc, Sm, Ta, Tb, Th, U, W, Yb; by ICP: Ag, Ba, Be, Co, Cr, Cu, Fe, La, Li, Mo, Na, Ni, Pb, Rb, Sc, Sr, V, Y, Zn, Zr [2].
Geophysical response	No response by IP or magnetic methods [4].
Primary dispersion	Strongest correlation with Au is shown by Ag, Bi and Te [4].
Secondary dispersion	The deposit is within a till Au anomaly extending for several kilometres from the deposit [3].
Exploration geologist(s) in charge	Outokumpu: Martti Kokkola.
ORE	
Siting of gold	Chiefly free gold in quartz veins, locally related to arsenopyrite, commonly with tellurides; minor amounts in aurostibite and tellurides [2,3,4].
Fineness	On average, 97% Au, 3% Ag [2].
Major opaques	Pyrrhotite [2,4].
Minor opaques	Ilmenite, arsenopyrite, chalcopyrite, loellingite, sphalerite, pyrite, marcasite, magnetite, galena, gold, altaite, tsumoite, tellurobismuthinite, rucklidgeite, maldonite, hedleyite, joseite-B, pilsenite, tetradymite, aurostibite, ullmannite, costibite [2,4].
Gangue	Quartz, scheelite, diopside, plagioclase, amphibole [2,4].
Ore composition	Diamond-drill core [1]: 41.00 ppm Au, 4.10 ppm Ag, 19 ppm As, 12.1 ppm B, 339 ppm Ba, 6.1 ppm Bi, 5 ppm Co, 133 ppm Cu, 20 ppb Hg, <1 ppm Mo, 13 ppm Ni, 51 ppm Pb, 66 ppm Rb, 5400 ppm S, 0.6 ppm Sb, 1.2 ppm Se, 213 ppm Sr, 5.200 ppm Te, 12.0 ppm Th, 12.4 ppm U, 90 ppm V, 240 ppm W, 147 ppm Zn; 68.1% SiO_2, 0.58% TiO_2, 12.6% Al_2O_3, 5.22% Fe_2O_3, 1.85% MgO, 4.34% CaO, 2.78% Na_2O, 1.99% K_2O, 0.12% P_2O_5, 0.85% LOI. Diamond-drill core, high-grade mineralisation [4]: 24.8 ppm Au, 0.2 ppm Ag, 48 ppm As, 289 ppm Ba, 5.7 ppm Be, 11.1 ppm Bi, 17 ppm Co, 36 ppm Cr, 5 ppm Cs, 210 ppm Cu, 10 ppm La, 23 ppm Li, 11 ppm Ni, <2 ppm Pb, 3500 ppm S, 0.5 ppm Sb, 15.7 ppm Sc, 1.3 ppm Se, 3.8 ppm Sm, <5 ppm Sn, 168 ppm Sr, 1.5 ppm Ta, 3.25 ppm Te, 4.5 ppm Th, 2.4 ppm U, 82 ppm V, 1410 ppm W, 19.6 ppm Y, 217 ppm Zn, 66 ppm Zr; 40.83% SiO_2, 0.32% TiO_2, 10.09% Al_2O_3, 11.25% Fe_2O_3, 16.77% MgO, 14.05% CaO, 1.15% Na_2O, 0.06% K_2O, 0.15% P_2O_5, 4.98% LOI.
Enriched elements	As, Ag, Au, Bi, K, S, Se, Te, W [1,4].
GEOLOGY	
Major host rocks	Mafic metavolc. rock [1]; gabbro-diorite [2,4]; andesitic porphyry [3].
Geological setting	The geotectonic environment is arc-accretionary [4]. The host rock is surrounded by mica gneisses, volcanogenic and arenitic metasedimentary gneisses and intermediate metavolcanic rocks, most of which have tonalitic to granodioritic composition [2,4]. The gold mineralisation is in shear zones chiefly hosted by the gabbro-diorite; the shear zones also extend into the wallrocks, but do not contain any gold mineralisation there [2,4].
Intrusives	The synorogenic intrusion, ranging from gabbro to quartz diorite in composition, forms host to and predates the mineralisation [2,4]. In addition, sets of granitic pegmatites, which both pre- and post-date the mineralisation [3].
METAMORPHISM	
Metamorphic grade	Amphibolite facies [2,4].
Metamorphic mineral assemblage	Gabbro-diorite: plagioclase-hornblende ± quartz, garnet; garnet is abundant near the contacts against mica gneisses and shear zones [2,4].

STRUCTURAL SETTING

Structural style	Brittle-ductile [2,4].
Controlling structure	A set of conjugate, brittle-ductile shear zones whose thickness is 10-15 m and extent at least 2.7 km [2,4]. The shear zones post-date the main deformation stage (D2), but predate deformation stages D3 and D4.
Deformation history	Four deformation stages, D1-D4, are detected; D2 is the main stage [2,4].
Veins	Quartz veins synchronous with shearing [2,3,4].
ALTERATION	
General alteration	Alteration, chiefly "skarnification", silicification and biotitisation with minor to moderate sericitisation and sulphidation; alteration is restricted to the shear zones [2,4].
TIMING	Probably syn-peak metamorphic, between D2 and D3: arsenopyrite replaces loellingite, no auriferous veining post-dating deformation, ilmenite common in the mineralisation, auriferous veins and shear zones cut across D2 axial plane foliation, but are folded during D3 and D4 [2].
GENETIC MODEL	Sequence of mineralisation [4]: I) magnetite-ilmenite-scheelite: "intense fracturing accompanied with skarn reactions and oxidic stage of mineralisation", II) arsenopyrite-loellingite-scheelite-pyrrhotite-arsenopyrite: "initial sulphide mineralisation stage", and III) pyrrhotite-chalcopyrite-sphalerite-arsenopyrite-pyrite-gold: "main sulphide mineralisation stage", and IV) gold-aurostibite-ullmannite-costibite-galena-maldonite-arsenopyrite-joseite-B-hedleyite-native bismuth-pilsenite-tsumoite-altaite: "precious metal mineralisation stage". According to internal relationships between ore minerals, most sulphide mineralisation (stage I and II) probably took place at 300-400°C; the final (second?) stage of precious metal mineralisation took place at or below 266°C [4].
FIGURES	[2]: Regional and local surface geology maps. [4]: Regional and local geology maps, photomicrographs on ore minerals.

References

1. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
2. Luukkonen, A., Grönholm, P. & Hannila, T. 1992. Eräiden Etelä-Suomen kulta- ja sen seuralaismetalliesiintymien geologiset pääpiirteet. Summary: Main geological features of certain gold and tungsten-tin-gold prospects in southern Finland. Geological Survey of Finland, Report of Investigation 113. 90 p.
3. Kokkola, M. 1995. Huittinen, Jokisivu. In: M. Kokkola & R. Lahtinen (eds) Syysekskursio Tampereen - Vammalan alueelle: ekskursio-opas 5.-6.10.1995. Vuorimiesyhdistys. Sarja B 58, 17-18. (in Finnish)
4. Luukkonen, A. 1994. Main geochemical features, metallogeny and hydrothermal alteration phenomena of certain gold and gold-tin-tungsten prospects in southern Finland. Geological Survey of Finland, Bulletin 377. 153 p.

Name	***Kaapelinkulma***
GENETIC TYPE	Orogenic 'mesothermal'.
LOCATION	
Geological domain	Svecofennian **Belt** Vammala Migmatite Zone
Map sheet	2132 03 **X coordinate** 6791330 **Y coordinate** 2506830
Municipality	Valkeakoski
Nearest town, access	5 km SE from Valkeakoski, 35 km SE from Tampere. 5 km to Highway 3, 4 km to a sealed road, 500 m to a gravel road.
MINING	
Exploration licence no.	4284/1, 6557/1.
Present holder	Outokumpu Oyj (1993-).
Previous holders	Geological Survey of Finland (GTK) (1986-1993).
Status of development	Prospect.
Resources	0.13 Mt 8.2 ppm Au [2].
Total in-situ gold	1035 kg [2].
Extent of mineralisation	At least, 900 m long [2,3].
Lodes	A set of lodes in a close array [1].
EXPLORATION	
Discovery	A gold-rich outcrop sample found 1986 by an amateur prospector who provided the sample to the GTK, this led to the discovery of the mineralised area in bedrock by GTK [2,3].
Exploration history	GTK (1986-1993) [2,3]: bedrock mapping, diamond drilling.
Drilling	GTK (1986-1991) [2]: 27 diamond-drill holes, total about 2 km.
Secondary dispersion	Regional and local Au and As anomalies in till envelop the deposit; the extent of the regional Au anomaly is 20 x 60 km [3].
Exploration geologist(s) in charge	GTK: Petri Rosenberg.
ORE	
Siting of gold	Gold is in thin stringers of sulphides and quartz, and is typically associated with arsenopyrite and pyrrhotite [2]. It occurs in fractures of quartz and as inclusions in arsenopyrite [2].
Major opaques	Arsenopyrite and pyrrhotite [2].
Minor opaques	Chalcopyrite, loellingite, native bismuth, native gold [2].
Gangue	Quartz, scheelite [2].
Ore composition	Diamond-drill core [1]: 3.25 ppm Au, 0.101 ppm Ag, 2300 ppm As, 5.5 ppm B, 340 ppm Ba, 25.2 ppm Bi, 18 ppm Co, 92 ppm Cu, <5 ppb Hg, <1 ppm Mo, 24 ppm Ni, <2 ppm Pb, 134 ppm Rb, 6420 ppm S, <0.2 ppm Sb, 0.18 ppm Se, 187 ppm Sr, 0.740 ppm Te, 3.8 ppm Th, 1.5 ppm U, 220 ppm V, 4 ppm W, 69 ppm Zn; 56.4% SiO_2, 0.81% TiO_2, 16.6% Al_2O_3, 9.03% Fe_2O_3, 3.38% MgO, 6.23% CaO, 2.70% Na_2O, 2.08% K_2O, 0.092% P_2O_5, 1.08% LOI.
Enriched elements	As, Au, Bi, K, S, Te, W [1,2].
GEOLOGY	
Major host rocks	Quartz diorite [1,2].
Minor host rocks	Tonalite and quartz diorite of the main intrusion [2].
Geological setting	The deposit is in the southern part of 40-50 km wide migmatite belt between Tampere and Hämeenlinna, in a sequence of mica gneisses and tonalitic intrusions, in an intermediate, dike-like, megalith within a tonalitic intrusion [2]. The intermediate dike represents an early sub-volcanic intrusion suite followed by the emplacement of the tonalite [2].
Intrusives	The deposit is hosted by an intermediate dike, 50-100 m wide and 1500 m long, which forms a gently dipping inclusion (large xenolith) in a synorogenic tonalite [2].
METAMORPHISM	
Metamorphic grade	Lower-amphibolite facies [2].
Metamorphic mineral assemblage	Intermediate dyke: plagioclase - hornblende - quartz [2].
STRUCTURAL SETTING	
Structural style	Brittle-ductile, dominantly ductile [2].
Controlling structure	A set of thin, NNE-trending sinistral shear zones. The width of the shear zones is from a few cm to several metres [2].
Deformation history	Multi-stage deformation [2].
Veins	Auriferous quartz veins [2].
ALTERATION	
General alteration	Biotitisation of hornblende with quartz as a by-product, tremolite selvages in some of the mineralised veins [2].

GENETIC MODEL Orogenic “mesothermal” deposit with an obvious structural control [2].

Post-mineralisation modifications

Post-gold mineralisation, NW-trending deformation [2].

FIGURES [2]: Regional and local surface geology maps, a cross section.

References

1. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991 Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
2. Rosenberg, P. 1997. The Kaapelinkulma gold deposit, Valkeakoski. In: C. Ehlers (ed.) Gold and base metal deposits in southwestern Finland. Geological Survey of Finland, Guide 44, 23-25.
3. Hakala, P. 1988. Malminetsintää palvelevat maaperätutkimukset Pirkkalassa ja Valkeakoskella, kl 2123 07 Lempäälä, 2132 03 Kaapelinkulma, 2123 05 Vatanen. Geological Survey of Finland, unpublished report P2.23.4.001. 8 p. (in Finnish)

Name	***Kivikesku (Koukkujärvi)***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Tampere Schist Belt
Map sheet	2123 06 **X coordinate** 6824730 **Y coordinate** 2474110
Municipality	Nokia
Nearest town, access	5 km to Nokia, 12 km from Tampere city centre. A gravel road to the area, 3 km to the Highway 11.
MINING	
Exploration licence no.	4890/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	5 m at 3.4 m Au [1].
Extent of mineralisation	Thickness 1-5 m [1].
Lodes	A set of small(?) lodes [1].
EXPLORATION	
Discovery	Au-rich boulder found by an amateur prospector, this led to discovery of a number of similar boulders and, later, bedrock mapping, investigation of Au and scheelite distribution in till, and drilling led to the mineralisation [1].
Exploration history	GTK (1990-94) [1]: Bedrock mapping, IP and magnetic ground survey within 1.5 km^2, till geochemistry, diamond drilling.
Drilling	GTK (1990-94): 14 diamond-drill holes [1].
Geophysical response	No response by IP or magnetic methods [1].
Secondary dispersion	Au, As and W anomalies in till envelop the deposit [1].
Exploration geologist(s) in charge	
	GTK: Boris Lindmark.
ORE	
Siting of gold	Free native gold and tiny (1 micron) gold inclusions in arsenopyrite [1].
Major opaques	Arsenopyrite, pyrrhotite [1].
Minor opaques	Pyrite, chalcopyrite, gold [1].
Gangue	Quartz, scheelite [1].
Enriched elements	Au, As, K, S, W [1].
GEOLOGY	
Major host rocks	Metagreywacke [1].
Geological setting	A volcano-sedimentary association, in the western part of the Tampere Schist Belt, intruded by a granodiorite; the deposit is in metagreywacke that is, partially, a large inclusion (xenolith) in the granodiorite, parallel and near the contact between the metasedimentary rock and the granitoid [1].
Intrusives	A synorogenic envelops the host rock [1].
ALTERATION	
Proximal alteration	Biotite-plagioclase-quartz-hornblende-tremolite [1].
GENETIC MODEL	Orogenic “mesothermal” deposit.

References

1. Lindmark, B. 1995. Tutkimustyöselostus Nokian kaupungin valtausalueella Koukkujärvi 1 (kaivosrekisterinro 4890/1) suoritetuista kultatutkimuksista vuosina 1990-1994. Geological Survey of Finland, unpublished report M06/2123/-95/1/10. 7 p. (in Finnish)

Name	***Tammijärvi***				
GENETIC TYPE	Orogenic ‘mesothermal’ ?				
LOCATION					
Geological domain	Svecofennian	**Belt**	Tampere Schist Belt		
Map sheet	3122 06	**X coordinate**	6857300	**Y coordinate**	3437200
Municipality	Luhanka				
Nearest town, access	5 km NE from Luhanka, 45 km S from Jyväskylä. 2 km to a sealed road, a gravel road to the area.				
MINING					
Present holder	OPEN FOR ACQUISITION.				
Previous holders	Rautaruukki (1950's-1960's), Outokumpu (1950's-1960's), Geological Survey of Finland (GTK) (1947-51, 1978-86).				
Status of development	Prospect.				
Best sections	4.5 m at 0.4 ppm Au and 0.84% Cu; 6 m at 0.92% W [1,2,3].				
Extent of mineralisation	The mineralised zone, consisting of six lodes, is subvertical to steeply SE dipping, generally 100 m (up to 500 m) wide and has an along-strike continuation for about six kilometres [1,2,3].				
Lodes	Six lodes known [1,2,3].				
EXPLORATION					
Discovery	Re-analysing of old boulder samples by the GTK revealed anomalous Sn and W concentrations; this led to the discovery of Au- and W-rich mineralisations by detailed glacial erratic boulder survey by the GTK during 1978 [3].				
Exploration history	GTK (1947-1951, 1978-1986) [1,3]: chiefly explored for W; bedrock mapping, conductivity, IP, VLF and magnetic ground surveys, till geochemistry, trenching, diamond drilling. Rautaruukki (1950's-1960's) [1,3]: bedrock mapping, low-altitude aeromagnetic survey. Outokumpu (1950's-1960's) [1]: bedrock mapping.				
Drilling	GTK (1980-1985) [1,3] 25 diamond-drill holes, total approx. 4 km, in profiles 50 m apart across the mineralised zone or across the supposed central part of the mineralised zone.				
Elements analysed	By XRF: major elements, Ba, Bi, Cr, Cu, Mo, Nb, Ni, Pb, Rb, S, Se, Sn, Sr, Tl, Y, W, Zn, Zr; by NAA: As, Au, Ce, Co, Cr, Cs, Eu, Hf, La, Lu, Nd, Sb, Sc, Sm, Ta, Tb, Th, U, W, Yb; by ICP: Ag, Ba, Be, Co, Cr, Cu, Fe, La, Li, Mo, Na, Ni, Pb, Rb, Sc, Sr, V, Y, Zn, Zr [1]. By AAS(?): Ag, Au, Bi, Cd, Co, Cu, Ni, Pb, Sb, Sn, W, Zn [3].				
Geophysical response	A weak IP response for the whole mineralised area [2,3].				
Primary dispersion	Strongest correlation with Au is shown by Ag, Bi and Te [2].				
Exploration geologist(s) in charge					
	GTK: Marjatta Virkkunen, Boris Lindmark.				
ORE					
Siting of gold	Chiefly in electrum which occurs associated with bismuth, some gold is in tellurides [1,2].				
Major opaques	Arsenopyrite [1,2,3].				
Minor opaques	Chalcopyrite, pyrrhotite, stannite, sphalerite, pyrite, native bismuth, marcasite, ilmenite, rutile, herzebergite, cassiterite, cubanite, clausthalite, Bi-selenide, galena, hessite, tellurobismuth, volynskite, electrum, native silver, argentie, Bi-Pb and Bi-Ag-Cu sulphosalts [1].				
Gangue	Quartz, scheelite, titanite [1,2,3].				
Ore composition	Diamond-drill core, high-grade mineralisation [2]: 19.9 ppm Au, 137 ppm Ag, 22000 ppm As, 338 ppm Ba, 3230 ppm Bi, 17.2 ppm Co, 31 ppm Cr, 6.1 ppm Cs, 2060 ppm Cu, 2.1 ppm Hf, <4 ppm La, 11 ppm Mo, 13 ppm Ni, <2 ppm Pb, 60 ppm Rb, 57.7 ppm Sb, 3.2 ppm Sc, 56.6 ppm Se, 0.9 ppm Sm, 584 ppm Sn, 0.2 ppm Ta, 52.4 ppm Te, 5.3 ppm Th, <2 ppm U, 45 ppm W, 152 ppm Zn, <48 ppm Zr.				
Enriched elements	Ag, As, Au, Bi, Cu, S, Sn, Te, W [1,2].				
GEOLOGY					
Major host rocks	Metagreywacke [1,2,3].				
Minor host rocks	Mafic and intermediate metavolcanic rocks [1,2].				
Geological setting	The geotectonic environment is arc-accretionary [2]. The deposit is in the easternmost part of the Tampere Schist Belt, which is here intruded by syn- and late-orogenic intrusions. The metasedimentary host rocks form a part of a dominantly felsic to intermediate sedimentary-volcanic sequence which locally has interbeds(?) of mafic metavolcanic rocks [1,2,3].				
Intrusives	Intrusives in the area are syn- and late-orogenic granodiorites [1,2].				
STRUCTURAL SETTING					
Deformation history	The dominant deformation is D1 which in its style resembles the dominant D1 stage throughout the Tampere Schist Belt [2].				
Veins	Arsenopyrite-bearing, gold-related quartz veins, up to 0.6 m wide, are mostly syn-D1 [1,2,3].				
ALTERATION					
General alteration	Intense sericitisation, possibly synvolcanic epithermal, pre-D1 [1].				

Proximal alteration Quartz-sericite-arsenopyrite-scheelite [1].

GENETIC MODEL Sequence of mineralisation [2]: I) pyrite-chalcopyrite-titanite-ilmenite-rutile during "the main metamorphic events", II) scheelite-arsenopyrite-cassiterite-pyrite: "the initial W-As-Fe mineralisation stage", III) pyrrhotite-rutile-chalcopyrite-cobanite-sphalerite-stannite-arsenopyrite-scheelite-herzenbergite: "the main Cu-Fe-Sn-Zn mineralisation stage", IV) Clausthalite-bismuth-galena-Bi-Ag-Cusulphosalts-Pb-Bi sulphosalts-argentite-hessite-tellurobismuth-volynskite-chalcopyrite-silver-electrum-pyrrhotite-Bi selenides-cassiterite: "the late precious metallic Bi-Ag-Te-Au stage", and V) supergenealteration. According to internal relationships between ore minerals, the final precious metal mineralisation, stage IV, took place at or below 266°C [1,2].

Post-mineralisation modifications

Minor supergene changes in the ore mineral assemblage [2].

FIGURES [1,2]: Regional and local geology maps.

References

1. Luukkonen, A., Grönholm, P. & Hannila, T. 1992. Eräiden Etelä-Suomen kulta- ja sen seuralaismetalliesiintymien geologiset pääpiirteet. Summary: Main geological features of certain gold and tungsten-tin-gold prospects in southern Finland. Geological Survey of Finland, Report of Investigation 113. 90 p.
2. Luukkonen, A. 1994. Main geochemical features, metallogeny and hydrothermal alteration phenomena of certain gold and gold-tin-tungsten prospects in southern Finland. Geological Survey of Finland, Bulletin 377. 153 p.
3. Lindmark, B. 1988. Tina- ja volframitutkimukset Luhangan Tammijärvellä vuosina 1978 - 1986. Geological Survey of Finland, unpublished report M19/3122/-87/1/10. 41 p. (in Finnish)

Name	***Vatanen***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Tampere Schist Belt
Map sheet	2123 05 **X coordinate** 6814320 **Y coordinate** 2478690
Municipality	Pirkkala
Nearest town, access	10 km SW from the Tampere city centre. A gravel road to the area, 1 km to a sealed road.
MINING	
Exploration licence no.	4179/1-2.
Present holder	Geological Survey of Finland (GTK).
Status of development	Prospect.
Best sections	Approximately 10 m at 0.5 ppm Au [1].
Extent of mineralisation	A few hundreds of metres long, width about 100m [1].
EXPLORATION	
Discovery	On 1987 by GTK: detection of regional Au-As anomalies on 1986 led to a detailed till geochemical and bedrock mapping which was followed by drilling into local anomalies; final discovery of the deposit by diamond drilling [1,2,3].
Exploration history	GTK (1987-89) [1,2,3]: Till geochemistry, bedrock mapping, trenching, IP ground survey, diamond drilling.
Drilling	GTK: 4 diamond-drill holes, total 504 m [1].
Elements analysed	Ag, Au, As, Co, Cr, Cu, Fe, Mn, Ni, Pb, S, Zn [1].
Geophysical response	No response by IP [1].
Secondary dispersion	Regional and local Au and As anomalies in till envelop the deposit; the extent of the regional Au anomaly is 20x60 km and the extent of the local Au anomaly is about 100 x 300 m [1,2,3].
Exploration geologist(s) in charge	
	GTK: Petri Rosenberg.
ORE	
Siting of gold	Inclusions in arsenopyrite [1].
Major opaques	Arsenopyrite [1].
Minor opaques	Pyrrhotite, pyrite, loellingite, chalcopyrite, gold [1].
GEOLOGY	
Major host rocks	Granodiorite (to diorite) [1].
Minor host rocks	Mica gneiss [1].
Geological setting	Sets of quartz veins in a synorogenic granodiorite body that is, possibly, a subvolcanic intrusion; the intrusion is surrounded by mica gneisses which predate the intrusion [1].
Intrusives	The granodioritic intrusion clearly predates gold mineralisation; minor, post-gold pegmatite granite dikes [1].
METAMORPHISM	
Metamorphic grade	Amphibolite facies [1].
Metamorphic mineral assemblage	Granodiorite: plagioclase - hornblende - quartz - biotite ± diopside [1].
STRUCTURAL SETTING	
Structural style	Dominantly brittle [1].
Veins	Auriferous quartz veins [1].
ALTERATION	
General alteration	Weak sulphidation: formation of arsenopyrite and pyrrhotite dissemination [1].
GENETIC MODEL	Orogenic “mesothermal” deposit.
Post-mineralisation modifications	
	Minor, post-gold pegmatite granite dykes [1].
FIGURES	[1]: Till anomaly maps, outcrop photographs, regional geology map, drilling profiles.

References

1. Rosenberg, P. 1990. Tutkimustyöselostus Pirkkalan kunnassa Vatanen 1, Lintumäki 1, Poikkiaro 1 sekä Sorkkala 1-2 nimisillä valtausalueilla, kaiv. rek. n:o 4179/1-2 ja 4331/1-3, suoritetuista tutkimuksista. Geological Survey of Finland, unpublished report M06/2123/-90/1/10. 58 p. (in Finnish)
2. Lestinen, P. 1987. Pirkkalan kohteen geokemialliset kultatutkimukset vuosina 1986-1987. Geological Survey of Finland, unpublished report S/41/2123/1/1987. 11 p. (in Finnish)
3. Hakala, P. 1988. Malminetsintää palvelevat maaperätutkimukset Pirkkalassa ja Valkeakoskella, kl 2123 07 Lempäälä, 2132 03 Kaapelinkulma, 2123 05 Vatanen. Geological Survey of Finland, unpublished report P2.23.4.001. 8 p. (in Finnish)

Name	***Liesjärvi***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Hämeenlinna schist belt
Map sheet	2113 08 **X coordinate** 6757000 **Y coordinate** 3488800
Municipality	Tammela
Nearest town, access	60 km S from Tampere. 2 km from a sealed road, a gravel roads to the area.
MINING	
Exploration licence no.	4235/1.
Present holder	Endomines Oy.
Previous holders	Outokumpu Oy (1988-94).
Status of development	Prospect.
Best sections	6 m at 2 ppm Au, including 1 m at 5 ppm Au [1].
Extent of mineralisation	Irregular variation in the extent of the Au mineralisation [1].
EXPLORATION	
Discovery	Several Au- and arsenopyrite-bearing boulder samples provided by amateur prospectors from the region; this led Outokumpu for further boulder sampling, till geochemistry and ground geophysics; mineralisation was detected by drilling into till and geophysical anomalies [1].
Exploration history	Outokumpu Oy (1988-94) [1]: till geochemistry, detailed bedrock mapping, ground VLF-R, slingram, IP and magnetic survey, diamond drilling.
Drilling	Outokumpu (1988-1992): 47 diamond-drill holes, total 2283 m [1].
Elements analysed	Au, As, Cu [1].
Exploration geologist(s) in charge	
	Outokumpu: Martti Kokkola.
ORE	
Major opaques	Arsenopyrite [1].
Minor opaques	Chalcopyrite [1].
Gangue	Quartz, tourmaline, scheelite [1].
Enriched elements	Au, As, B, Cu, S, W [1].
GEOLOGY	
Major host rocks	Granodiorite [1].
Geological setting	A synorogenic(?) granodiorite has intruded into a sequence of felsic, intermediate and mafic metavolcanic rocks and volcanogenic metasedimentary rocks [1].
Intrusives	A synorogenic(?) granodiorite which predates mineralisation [1].
STRUCTURAL SETTING	
Closest major shear	A few km to the south of the area: a WSW-trending shear zone, it also forms the contact between the granodiorite and mafic metavolcanic rocks [1].
Controlling structure	A set or sets of shear zones near the eastern contact of the granodiorite apparently host the mineralisation [1].
GENETIC MODEL	Orogenic “mesothermal” deposit.

References

1. Kokkola, M. 1986. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Tammela, Liesjärvi, Liesjärvi 2, Lunkinjärvi 1-2, Lammaslammi, Puolikkaansuo, Letonpää, kaiv. rek. n:o 4235/1, 4358/2, 4358/3-4, 4366/1, 4639/1, 4358/1. Outokumpu Oy, unpublished report 080/2113/MK/94. 3 p. (in Finnish)

Name	***Mäkrä***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Central Finland
Map sheet	3311 11 **X coordinate** 6999180 **Y coordinate** 3459010
Municipality	Viitasaari
Nearest town, access	17 km E from Viitasaari, 80 km NNE from Jyväskylä. A gravel road to the area, 4 km to a sealed road.
MINING	
Exploration licence no.	3385/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK) (1957-58, 1982-86).
Status of development	Prospect.
EXPLORATION	
Discovery	Au-rich erratic boulders found by GTK during copper exploration on 1957-58; a follow-up using trenching led to discovery of the deposit on 1982 by GTK [1].
Exploration history	GTK (1957-58, 1982-86) [1]: Glacial erratic boulder mapping, bedrock mapping, trenching, till geochemistry, diamond drilling, ground magnetic and slingram survey; 1983: reanalysis of old drill core for Cu, Co and Au.
Drilling	GTK (1957-58): 5 diamond-drill holes.
Elements analysed	Cu, Co and Au [1].
Geophysical response	Magnetic and electric: no response [1].
Exploration geologist(s) in charge	
	GTK: Jarmo Nikander.
ORE	
Siting of gold	Apparently, gold only occurs in quartz veins and is associated with arsenopyrite [1].
Major opaques	Arsenopyrite, pyrrhotite [1].
Minor opaques	Pyrite, gold [1].
Gangue	Quartz [1].
GEOLOGY	
Major host rocks	Intermediate metavolcanic rock [1].
Minor host rocks	Mafic metavolcanic rock [1].
Geological setting	Intermediate-mafic metavolcanic sequence [1].
METAMORPHISM	
Metamorphic grade	Amphibolite facies [1].
STRUCTURAL SETTING	
Veins	Auriferous, arsenopyrite-bearing quartz veins [1].
GENETIC MODEL	Orogenic “mesothermal” deposit.

References

1. Nikander, J. 1987. Malmitutkimukset Viitasaaren kunnassa valtausalueilla Iso-Mäkrälampi 1, kaiv. rek. n:o 3385/1 ja Suovanlahti kaiv. rek. n:o 3890/1. Geological Survey of Finland, unpublished report M06/3311/-87/1/10. 4 p. (in Finnish)

Name	***Pääjärvi***				
GENETIC TYPE	Orogenic ‘mesothermal’.				
LOCATION					
Geological domain	Svecofennian	**Belt**	Hämeenlinna schist belt		
Map sheet	2134 04	**X coordinate**	6771000	**Y coordinate**	3556000
Municipality	Lammi				
Nearest town, access	6 km E from Lammi, 40 km NE from Hämeenlinna. A sealed road to the area.				
MINING					
Exploration licence no.	2902/1-2.				
Present holder	OPEN FOR ACQUISITION.				
Previous holders	Outokumpu Oy (1978-1981).				
Status of development	Prospect.				
Best sections	1 m at 2.9 ppm Au with up to 3% Cu [1].				
EXPLORATION					
Discovery	By Outokumpu on 1978: a mineralised outcrop found by an amateur prospector led to the discovery of the mineralisation during local exploration [1].				
Exploration history	Outokumpu (1978-1981) [1]: bedrock mapping, magnetic and VLF ground survey, till and soil geochemistry, diamond drilling.				
Drilling	Outokumpu (1978-1981): 15 diamond-drill holes, total 1181 m [1].				
Elements analysed	Au, Cu [1].				
Exploration geologist(s) in charge					
	Outokumpu: Ulla Mäkelä.				
GEOLOGY					
Major host rocks	Mica schist [1].				
Minor host rocks	Intermediate and mafic metavolcanic rocks [1].				
Geological setting	A metavolcanic-metasedimentary sequence [1].				
STRUCTURAL SETTING					
Structural style	Ductile (?).				
Closest major shear	Pappilanlahti shear zone [1].				
GENETIC MODEL	Orogenic “mesothermal” deposit.				

References

1. Mäkelä, U. 1981 Kaivoslain 19 pykälän mukainen tutkimustyöselostus: Lammi, Pääjärvi. Outokumpu Oy, unpublished report 080/2134 04/UM/1981. 1 p. (in Finnish)

Name	***Satulinmäki***
GENETIC TYPE	Orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Hämeenlinna schist belt
Map sheet	2024 06 **X coordinate** 6737550 **Y coordinate** 2470850
Municipality	Somero
MINING	
Exploration licence no.	3421/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Outokumpu Oyj (1980-82).
Status of development	Prospect.
Best sections	0.5-1 m sections at, up to, 4.65 ppm Au [1].
EXPLORATION	
Discovery	On 1980: first indications were Au-rich samples from glacial erratic boulders found by amateur prospectors.
Exploration history	Outokumpu (1980-82) [1]: bedrock mapping, percussion drilling.
Drilling	Outokumpu (1980-82) [1]: systematic percussion drilling.
Elements analysed	By AAS: Ag, Au, Cu, Co, Fe, Hg, Mn, Mo, Ni, Pb, S, W, Zn; by XRF: major elements, Ba, Cr, P, Sr, Zr [1].
Exploration geologist(s) in charge	
	Outokumpu: Ulla Mäkelä, Ingmar Haga.
ORE	
Gangue	Quartz, tourmaline [1].
GEOLOGY	
Major host rocks	Aplite dykes [1]
Geological setting	The area is dominated by a sequence of metavolcanic rocks. The deformed aplites are in the contact zone of intermediate tuffite and mafic metalava(?). The aplites host auriferous quartz-tourmaline breccias. [1]
Intrusives	Aplite, which forms host to ore [1].
GENETIC MODEL	Orogenic “mesothermal” deposit.

References

1. Haga, I. 1984. Kaivoslain 19 pyk. mukainen tutkimustyömaaselostus: Somero, Satulinmäki. Outokumpu Oy, unpublished report 080/202 06/IEH/1984. 2 p. (in Finnish)

Name	***Vatsa***				
GENETIC TYPE	Orogenic ‘mesothermal’.				
LOCATION					
Geological domain	Svecofennian	**Belt**	Central Finland		
Map sheet		**X coordinate**	0	**Y coordinate**	0
Municipality	Korpilahti				
Nearest town, access	110 km ENE from Tampere, 40 km S from Jyväskylä.				
MINING					
Present holder	Terra Mining (William Resources Inc.).				
Status of development	Prospect.				
Resources	1 Mt at 1.73 ppm Au [2].				
Total in-situ gold	1830 kg [2].				
Best sections	7 m at 6.5 ppm Au [1].				
Extent of mineralisation	20-50 m wide, 800 m (possibly 1400 m) long, open at both ends along strike and in depth; there also may be parallel mineralised structures [1,2].				
EXPLORATION					
Discovery	By Terra Mining [2] on 1992: RC drilling into a till geochemical anomaly.				
Exploration history	Terra Mining (1992-) [1,2]: till geochemical survey, diamond and RC drilling.				
Drilling	Terra Mining (1992, 1996-1997) [1]: 30 drill holes.				
Exploration geologist(s) in charge					
	Terra Mining: Tapio Lehto.				
ORE					
Major opaques	Pyrite, arsenopyrite [2].				
Gangue	Quartz [2].				
GEOLOGY					
Major host rocks	Gabbro [2]				
Minor host rocks	Pegmatitic granite [2]				
Geological setting	The deposit is in a contact zone beween a 1.89-1.88 Ga(?) synorogenic gabbro and a later, pegmatitic, granite [2].				
Intrusives	Both(?) gabbro and granite host and predate gold mineralisation [2].				
STRUCTURAL SETTING					
Controlling structure	A shear zone at contact between a gabbro and a pegmatitic granite [2].				
Veins	Auriferous quartz-pyrite-arsenopyrite veins [2].				
GENETIC MODEL	Orogenic “mesothermal” deposit.				

References

1. William Resources Inc. 1997. Press release 16/4/1997.
2. Lehto, T. 1998. Personal communication 21/12/1998.

Name	***Järvenpää***
GENETIC TYPE	Metamorphosed epithermal.
LOCATION	
Geological domain	Svecofennian **Belt** Tampere Schist Belt
Map sheet	2124 04 **X coordinate** 6837100 **Y coordinate** 2475300
Municipality	Ylöjärvi
Nearest town, access	10 km N from Ylöjärvi, 22 km NW from the Tampere city centre. A gravel road to the area, 1 km to a sealed road.
MINING	
Exploration licence no.	4901/1.
Present holder	Outokumpu Oyj (1990-).
Previous holders	Geological Survey of Finland (GTK) (1937-1947), Oy Lohja Ab (1983-1990).
Status of development	Prospect.
Best sections	More than 2 m at >2 ppm Au [3].
EXPLORATION	
Discovery	By GTK during 1937, based on bedrock mapping as a follow-up of a pyrite-rich galcial erratic boulder sample found by an amateur prospector.
Exploration history	GTK (1937-1947) [1,2]: bedrock mapping, magnetic and electric ground survey, diamond drilling. GTK (1985) [3]: exploration in the Lepomäki area, 1-2 km W from the Järvenpää deposit. Detailed bedrock mapping, whole-rock geochemical. analyses: anomalous Au values detected, up to 0.4 ppm. Lohja (1983-1990) [1,2]: bedrock mapping, diamond drilling.
Drilling	GTK (1937-1947): 11 diamond-drill holes, total 1600 m [1].
Elements analysed	By XRF: major elements, Ba, Bi, Cr, Cu, Mo, Nb, Ni, Pb, Rb, S, Se, Sn, Sr, Tl, Y, W, Zn, Zr; by NAA: As, Au, Ce, Co, Cr, Cs, Eu, Hf, La, Lu, Nd, Sb, Sc, Sm, Ta, Tb, Th, U, W, Yb; by ICP: Ag, Ba, Be, Co, Cr, Cu, Fe, La, Li, Mo, Na, Ni, Pb, Rb, Sc, Sr, V, Y, Zn, Zr [1,2]. By NAA: Ag, As, Au, Ba, Br, Co, Cr, Cs, Fe, La, Lu, Mo, Na, Ni, Rb, Sb, Sc, Sm, Sn, Ta, Th, U, W [3].
Primary dispersion	Schistosity-parallel Au anomalies (>0.1 ppm Au) are 5-20 m wide and at least 500-600 m long; these, apparently, are related to Zn and Ag anomalies of unknown extent [1,2]. However, the strongest correlation with Au is shown by Ag, Bi and Te [1].
Exploration geologist(s) in charge	Lohja: H. Ollila; Outokumpu: Esa Sandberg; GTK: Olli Sarapää.
ORE	
Siting of gold	Chiefly in electrum which is associated with compact sulphide spots and Pb-Sb mineral clusters; the grain size of electrum is 6-20 microns; some gold is native and in aurostibite [2].
Major opaques	Pyrite [1,2].
Minor opaques	Sphalerite, galena, chalcopyrite, pyrrhotite, fahlore, ullmannite, gudmundite, jamesonite, bournonite, boulangerite, arsenopyrite, rutile, electrum, native antimony, hessite, altaite, gold, aurostibite [1,2].
Ore composition	Diamond-drill core, high-grade mineralisation [1]: 8.20 ppm Au, 6.37 ppm Ag, 190 ppm As, 504 ppm Ba, 35.6 ppm Bi, 12 ppm Co, 150 ppm Cr, 7250 ppm Cu, 48 ppm F, 4.5 ppm La, 17 ppm Mo, 119 ppm Ni, 679 ppm Pb, 62 ppm Rb, 970 ppm Sb, 15.3 ppm Se, <5 ppm Sn, 20.40 ppm Te, 110 ppm V, 20 ppm W, 2028 ppm Zn, 61 ppm Zr; 75.43% SiO_2, 0.38% TiO_2, 8.21% Al_2O_3, 8.74% Fe_2O_3, 0.17% MgO, 0.11% CaO, 0.17% Na_2O, 2.53% K_2O, 0.05% P_2O_5, 4.11% LOI.
Enriched elements	Ag, Au, Ba, Cu, K, Pb, Rb, S, Sb, Se, Te, Zn [1,2].
GEOLOGY	
Major host rocks	Intermediate metavolcanic rock [1,2].
Geological setting	The geotectonic environment is arc-accretionary [1]. The deposit is located in a sequence of metasedimentary and intermediate and mafic metavolcanic rocks close to contact between the volcano-sedimentary sequence and a synorogenic porphyritic granodiorite [1,2].
Intrusives	A large intrusion of synorogenic granodiorite 100-200 m from the deposit forming part of the Central Finland Batolith [1,2].
METAMORPHISM	
Metamorphic history	F1 (D1) and regional peak metamorphism are synchronous [1,2].
Metamorphic grade	Transitional between upper-greenschist and lower-amphibolite facies, or at lower-amphibolite facies, T = 500-600°C, p = 1.5-3 kbar [1,2].
Metamorphic mineral assemblage	Hornblende-plagioclase-quartz-biotite ± albite, epidote, calcite [1,2].
STRUCTURAL SETTING	
Closest major shear	100-200 m NE from the deposit: the NW-trending contact between the volcano-sedimentary sequence and synorogenic granodiorite [1,2].
Controlling structure	Possibly, the contact between the supcrustal sequence and the granodiorite [1,2].
Deformation history	Three deformation stages (D1-D3); D1 is the dominant and plastic, D2 and D3 are weaker, brittle [1,2].

ALTERATION

General alteration	Intense sericitisation [1,2] suggesting metamorphosed and deformed, epithermal (argillic, advanced argillic, and/or adularia-sericite) alteration. For an alternative explanation, see "Timing".
Proximal alteration	Sericite-quartz-pyrite-rutile ± plagioclase (albite?), biotite, chlorite, apatite, garnet, fluorite, titanite [2].
TIMING	Mineralisation and alteration are synmagmatic, epithermal, if not taken place during D1; gold mineralisation may, also, be later, related to D2 or even D3 [2].
GENETIC MODEL	Sequence of mineralisation [1]: I) pyrite-rutile-pyrrhotite-chalcopyrite-arsenopyrite: "metasomatic silicification of intermediate metavolcanic rocks", II) pyrite-chalcopyrite-pyrrhotite-sphalerite: "formation of compact sulphide concentrates and formation of quartz veins", III) ullmannite-chalcopyrite-electrum-fahlores-pyrite: "Au-Ag mineralisation of compact sulphide concentrates", and IV) fahlores-bourninite-jamesonite-boulangerite-galena-pyrrhotite-arsenopyrite-gudmundite-hessite-altaite-antimony-electrum-aurostibite: "polymetallic Sb-Pb-Au-Ag stage". In any case, according to internal relationships between ore minerals, the final precious metal mineralisation took place at or below 280°C and below 2.9 kbar [1].
FIGURES	[2]: Regional and local geology maps. [1]: Regional and local geology maps, cross sections, photomicrographs on ore minerals.

References

1. Luukkonen, A. 1994. Main geochemical features, metallogeny and hydrothermal alteration phenomena of certain gold and gold-tin-tungsten prospects in southern Finland. Geological Survey of Finland, Bulletin 377. 153 p.
2. Luukkonen, A., Grönholm, P. & Hannila, T. 1992. Eräiden Etelä-Suomen kulta- ja sen seuralaismetalliesiintymien geologiset pääpiirteet. Summary: Main geological features of certain gold and tungsten-tin-gold prospects in southern Finland. Geological Survey of Finland, Report of Investigation 113. 90 p.
3. Sarapää, O. 1987. Kultatutkimukset Tampereen liuskejaksolla kesällä -85.Geological Survey of Finland, unpublished report M19/2124/-87/2/10. 5 p. (in Finnish)

Name	***Kutemajärvi***
GENETIC TYPE	Metamorphosed epithermal.
LOCATION	
Geological domain	Svecofennian **Belt** Tampere Schist Belt
Map sheet	2142 01 **X coordinate** 6838400 **Y coordinate** 2508500
Municipality	Orivesi
Nearest town, access	11 km W from Orivesi, 25 km NE from Tampere. 3 km from a sealed road (Highway 9), a gravel road to the area.
MINING	
Mining concession no.	2676/1a.
Present holder	Outokumpu Oyj (1990-).
Previous holders	Viento Oy (1946), Renlundin Tiili Oy (1946-57), private claim (1958-1961), Suomen Mineraali Oy - Paraisten Kalkkivuori Oy (1961-1964), Kemira Oy (1966-74), Oy Lohja Ab (1975-90).
Status of development	Open pit and underground.
When mined	1994-.
Resources	1993: 0.45 Mt 7.4 ppm Au; 0.4 Mt 8.4-11.3 ppm Au [2].
Total production	1994-97: 4420 kg [1,2,14].
Total in-situ gold	6.6 t [2].
Lodes	At least five economic, pipe-shaped, subvertical lodes and, probably, several smaller mineralised zones with similar geometry. The length (vertical extent) of the biggest known lode is >300 m; horizontal extent of the pipes is 10-20 m x 20-50 m [3,7].
EXPLORATION	
Discovery	First claim in the area in 1946, for kaolin, by Viento Oy. Exploration for gold started in 1981 by Lohja, and the mineralisation was detected on 1982 by diamond drilling that followed lithogeochemical exploration [3,7,8,13].
Exploration history	Renlundin Tiili Oy (1946-57) [3,7,8,13]: Exploration and evaluation of the sericite-rich rock as a raw material for brick making. Kemira Oy (1966-74) [7,8,13]: Exploration and evaluation of the sericite-rich rock as a resource for Al and K, and exploration for topaz; bedrock mapping, diamond drilling. Oy Lohja Ab (1975-1990) [3,7,8,13] : Started as sericite and quartz exploration work, gold exploration followed on 1981; diamond drilling, bedrock mapping, lithogeochemical mapping, pilot plant tests. Outokumpu Oyj (1990-) [3,7,8,13]: diamond drilling, trenching, till geochemical mapping, pilot plant tests.
Drilling	Kemira Oy (1960's) [8]: 3 diamond-drill holes. Oy Lohja Ab (1975-1990) [8] : 15 km of diamond drilling.
Elements analysed	By XRF: major elements, Ba, Bi, Cr, Cu, Mo, Nb, Ni, Pb, Rb, S, Se, Sn, Sr, Tl, Y, W, Zn, Zr; by NAA: As, Au, Ce, Co, Cr, Cs, Eu, Hf, La, Lu, Nd, Sb, Sc, Sm, Ta, Tb, Th, U, W, Yb; by ICP: Ag, Ba, Be, Co, Cr, Cu, Fe, La, Li, Mo, Na, Ni, Pb, Rb, Sc, Sr, V, Y, Zn, Zr [3,11]. By XRF: major components, Ba, Sr, Ti and Zr; by NAA: Sc and Th [13].
Economic evaluations	Feasibility study by Outokumpu Oy 1993-1994.
Geophysical response	Lodes correlate with positive IP and negative magnetic anomalies and are related to large-scale electric anomalies which extend for several 100s of metres to the depth [7,11].
Primary dispersion	A combined parameter Cu-Ni-Ag-Co-Zn-Pb defines an anomaly extending 50-1000 m from the deposit, and has a size of 500 x 1500 m [7]. Au and Te show a good positive correlation [8]. Local background (= the outer parts of the anomaly) for Au in the sericite schist is 10-80 ppb [13]. Indications of negative Sc and positive Th anomalies surrounding the ore pipes [13]; loss of Sc may be just apparent, due to dilution effects of intense alteration.
Secondary dispersion	No indications in the whole-Finland or regional till anomaly maps (1 sample per 300 km^2 and 1 sample per 4 km^2); there are local Au and Te anomalies (1 sample/250 x 250 m and 1 sample/50 x 50 m) extending up to 300 m from the ore [9]
Exploration geologist(s) in charge	Lohja: H. Ollila; Outokumpu: Martti Kokkola.
ORE	
Siting of gold	Native gold (the main Au carrier) occurs mainly along quartz grain boundaries, but also in symplectites with tellurides, in addition, Au-tellurides are common [4,7,8]. Typical grain size for gold is 5-10 micrometres, but may vary between 0.5 and 50 micrometres [7,8,10,11].
Fineness	94.9% Au, 2.4% Ag, 2.1% Pb [4].
Major opaques	Altaite [3,4,7,11].
Minor opaques	Pyrite, tellurobismuthinite, frohbergite, hessite, pyrrhotite, calaverite, chalcopyrite, coloradoite, sphalerite, galena, rutile, haematite, magnetite (in mafic precursors), arsenopyrite, cubanite, krennerite, native tellurium, native lead, petzite, boulangerite, bournonite [3,4,7,8,11,13].
Gangue	Quartz, sericite, pyrophyllite, andalusite, topaz [3,4,8,11,13].
Ore composition	Diamond-drill core [11]: 3.56 ppm Au, 0.86 ppm Ag, 66 ppm As, 150 ppm Ba, 28 ppm Bi, 2 ppm Ce,5 ppm Co, 19 ppm Cr, 20 ppm Cu, 2.4 ppm Dy, 3.6 Gd, 1330 ppm F, 22.8 ppm La, 1 ppm Mo, 1,4 Nd, 19 ppm Ni, 50 ppm Pb, 30 ppm Rb, 5.8 ppm Sb, 7.2 ppm Sc, 4.9 ppm Se, 6.2 ppm Sm, 11 ppm Sn, 0.3 ppm Ta, 36.00 ppm Te, 1.1 ppm Th, 3.1 ppm U, 49 ppm V, 1.8 ppm W, 460 ppm Zn, 74 ppm Zr; 84.97% SiO_2, 0.30% TiO_2, 8.62% Al_2O_3, 2.73% Fe_2O_3, 0.23% MgO, 0.07% CaO, 0.31% Na_2O, 2.00% K_2O, 0.05% P_2O_5, 1.90% LOI.

Enriched elements	Au, Ag, As, Bi, F, K, S, Sb, Se, Si, Te, Zn [3,11,13].
Ore fluid	H_2O-CO_2±CH_4 fluid with <7% NaCl eq., S-poor, Te-rich metamorphic fluid from volcanic and sedimentary rocks mixed with magmatic fluid from syn-orogenic intrusions [3,4,11,13]. On the other hand, the fluids related to the extensive alteration probably were acidic, F- and Cl(?)-rich [8], that is, typical for epithermal systems.
Pb isotope data	Galena Pb-Pb gives a homogeneous 1888 Ma model age [6].
GEOLOGY	
Major host rocks	Intermediate metavolc. rock or volcanogenic metasedim. rock [3,11,13].
Geological setting	Tampere schist belt: Continental island-arc type, Palaeoproterozoic, volcanosedimentary, arc-accretionary setting in the central part of the Svecofennian (1.75-2.0 Ga) domain; practically all rocks in the Tampere schist belt have an age of 1.90-1.88 Ga, the volcanic rocks have U-Pb zircon ages from 1904±4 Ma to 1889±5 Ma [3,5,6,13]. The deposit is in a sequence comprising felsic, intermediate and mafic metavolcanic (calc-alkaline) and volcanogenic metasedimentary rocks [3,11,13].
Intrusives	A hypabyssal(?) tonalitic to monzogranitic, porphyry intrusion 500 m N from the deposit; the surface extent of this Pukala Granitoid is 1-2 km x 15 km [3,4,8,13].
METAMORPHISM	
Metamorphic history	Metamorphism during intense period of magmatism at 1.88 ± 0.01 Ga at 470-570°C and 3-4 kbar [5].
Metamorphic grade	Low-pressure domain of transition from greenschist to amphibolite facies [5,8] or upper-greenschist facies [13].
Metamorphic mineral assemblage	Intermediate metavolc. rocks: quartz-biotite-plagioclase ± K feldspar, hornblende, epidote, magnetite, calcite, pyrite [3,11,13]
STRUCTURAL SETTING	
Structural style	Brittle-ductile [4].
Closest major shear	E-W trending Paarlahti-Iso Teerjärvi Shear Zone 200 m south of the deposit [4,8,13].
Controlling structure	The altered and mineralised area is in the intersection of NW-SE and E-W trending faults [4,13].
Deformation history	Four-phase deformation [3,4,5,8]. D1 is characterised by tight, isoclinal folding and E-W trending foliation; D2 is indicated by crenulation and D3 or D4 by kink banding [13].
Ore fabric	Lepido-granoblastic, massive (dominant) to intensely foliated [3,11,13].
Veins	In the deposit, quartz veins are mostly syn- to late-kinematic, of syn-D2 and syn-D3 deformation stages, respectively [4].
ALTERATION	
General alteration	Extensive and intense alteration; textures and mineral assemblages strongly suggest metamorphosed and deformed, epithermal - argillic, advanced argillic, and/or, most probably, adularia-sericite type - alteration. Altered rock are presently: quartz-sericite schist (dominant), quartz-andalusite-pyrophyllite schist, quartz rock, quartz-topaz rock and topaz rock, all of these are derived from intermediate volcanic precursors [3,4,11,13]. At least, the prominent alteration, if not gold mineralisation, predates D1 deformation [13]. The extent of alteration in the present surface is <0.5 km^2 (400 m x 1 km) and it extends to the depth of at least 450 m [3,4,8,11,13].
Proximal alteration	Pyrophyllite-quartz or sericite-quartz ± andalusite, topaz, fluorite, kaolinite, rutile, apatite, tellurides, gold, and, rarely, sulphides, tourmaline; in primarily more mafic types also magnetite, chlorite and/or phlogopite are present and there is more commonly pyrite [3,4,8,11,13].
Distal alteration	Mineral assemblage: quartz-sericite-chlorite-pyrite-rutile; in originally more mafic rocks, also chlorite may be present; more sericite than in the most intensely altered areas [3,4,8,11,13].
TIMING	Synmagmatic, early, pre-metamorphic, pre-regional deformation [12].Post-peak metamorphic, probably 1.89-1.885 Ga [4]. Galena Pb-Pb gives a homogeneous 1888 Ma model age [6]. Monazite U-Pb: 1880 Ma; no reliable zircon ages obtained [6].
GENETIC MODEL	[12]: Both alteration and gold mineralisation predate deformation and are, probably, epithermal.Sequence of mineralisation [11]: I) cassiterite-ilmenite-magnetite-pyrite during "the initial mineralisation related to host rock alteration", II) pyrite-pyrrhotite-chalcopyrite-cubanite-sphalerite-galena-arsenopyrite-boulangerite-bournonite-terahedrite: "the sulphide mineralisation stage", III) bornite-altaite-frohbergite-hessite-galena-electrum-tellurium-calaverite-pyrite-krennerite-petzite-gold-arsenopyrite-coloradoite: "the telluride mineralisation stage", IV) gold-copper-lead-antimony-aurostibite-arsenopyrite: "the residual metallic stage", and V) supergene alteration. [4,11]: "Post-peak metamorphic sulphide ± gold precipitation at 320-380°C, 2.0-2.8 kbar, resulted from the interaction between the wallrocks and a low-salinity, <7% NaCl eq., H_2O-CO_2±CH_4 hydrothermal fluid. Phase separation due to local pressure fluctuations may have caused gold-telluride ± sulphide precipitation at 270-330°C and 0.7-1.6 kbar. Late brittle deformation and hydraulicfracturing opened pathways for large volumes of CO_2-CH_4±N_2 fluids, allowing a possible gas-phase transport of Te and Au(?)."
Post-mineralisation modifications	
	Retrograde kaolinisation of andalusite [3,13]. All regional deformation and metamorphism and related fluid activity post-date gold mineralisation? [12].
FIGURES	[3]: Regional and local geology maps [4]: Regional and local geology maps, detailed surface geology of one of the pipes (lodes), photomicrographs on ore minerals. [6]: A coloured map for regional and local surface geology. [11]: Regional and local geology maps, cross sections, photomicrographs on ore minerals. [13]: Coloured maps for regional and local surface geology, outcrop and thin section (silicates and ore minerals) photographs.

References

1. Outokumpu Oy 1996. Annual Report 1995. Espoo.
2. Outokumpu Oy 1997. Annual Report 1996. Espoo.
3. Luukkonen, A., Grönholm, P. & Hannila, T. 1992. Eräiden Etelä-Suomen kulta- ja sen seuralaismetalliesiintymien geologiset pääpiirteet. Summary: Main geological features of certain gold and tungsten-tin-gold prospects in southern Finland. Geological Survey of Finland, Report of Investigation 113. 90 p.
4. Poutiainen, M. & Grönholm, P. 1996. Hydrothermal fluid evolution of the Palaeoproterozoic Kutemajärvi gold telluride deposit, Southwest Finland. Economic Geology 91, 1335-1353.
5. Kilpeläinen, T., Korikovsky, S., Korsman, K. & Nironen, M. 1994. Tectono-metamorphic evolution in the Tampere-Vammala area. Geological Survey of Finland, Guide 37, 27-34.
6. Mänttäri, I., Luukkonen, A. & Grönholm, P. 1997. Isotopic studies on the Kutemajärvi gold deposit, Orivesi, southern Finland. Geological Survey of Finland, Special Paper 23, 55-58.
7. Ollila, H. A., Saikkonen, R., Moisio, J. & Kojonen, K. 1990. Kutemajärven kultaesiintymä. English summary: The gold deposit area in Kutemajärvi, Orivesi. Vuoriteollisuus 48, 26-30.
8. Grönholm, P. 1995. Oriveden Kutemajärven epiterminen kultaesiintymä. In: M. Kokkola & R. Lahtinen (eds) Syysekskursio Tampereen - Vammalan alueelle: ekskursio-opas 5.-6.10.1995. Vuorimiesyhdistys. Sarja B 58, 6-12. (in Finnish)
9. Kokkola, M. 1995. Irtomaapeite ja moreenigeokemialliset tutkimukset Kutemajärvellä. In: M. Kokkola & R. Lahtinen (eds) Syysekskursio Tampereen - Vammalan alueelle: ekskursio-opas 5.-6.10.1995. Vuorimiesyhdistys. Sarja B 58, 13. (in Finnish)
10. Saarnio, H. 1995. Oriveden kaivos. In: M. Kokkola & R. Lahtinen (eds) Syysekskursio Tampereen - Vammalan alueelle: ekskursio-opas 5.-6.10.1995. Vuorimiesyhdistys. Sarja B 58, 14-15. (in Finnish)
11. Luukkonen, A. 1994. Main geochemical features, metallogeny and hydrothermal alteration phenomena of certain gold and gold-tin-tungsten prospects in southern Finland. Geological Survey of Finland, Bulletin 377. 153 p.
12. Sorjonen-Ward, P. 1997. Personal communication 3/10/1997.
13. Grönholm, P. 1992. Oriveden Kutemajärven kultaesiintymän ja sen ympäristön geologia. Unpublished MSc thesis, Department of Geology, University of Helsinki. 115 p. (in Finnish)
14. Outokumpu Oy 1998. Annual Report 1997. Espoo.

Name	***Kuervitikko***
GENETIC TYPE	Skarn- or ironstone-hosted.
LOCATION	
Geological domain	Lapland **Belt** Kolari
Map sheet	2714 11 **X coordinate** 7500400 **Y coordinate** 2498800
Municipality	Kolari
Nearest town, access	30 km NNE from Kolari. 8 km from a sealed road, a gravel road adjacent to the area.
MINING	
Exploration licence no.	5082/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Rautaruukki Oy (1974-1987), Geological Survey of Finland (GTK) (1992-1995).
Status of development	Prospect.
Resources	1.2 Mt, grade ? [2].
Lodes	Two Au-Cu lodes and two Fe-Cu-Au lodes [2]
EXPLORATION	
Discovery	By Rautaruukki on 1980's [2].
Exploration history	Rautaruukki 1974-1987 [2,4]: Bedrock mapping, till geochemical survey, trenching, diamond drilling.
	GTK 1992-1995 [2]: Re-evaluation and reanalysis of the Rautaruukki data.
Drilling	Rautaruukki 1974-1987 [2] 32 diamond-drill holes, total 2417 m.
Elements analysed	Ag, Au, Bi and Te by GFAAS; As, Co, Cu, Fe, Mn, Mo, Ni, Pb, Zn by ICP [2].
Geophysical response	Good response on magnetic and gravity methods [3].
Primary dispersion	Moderate to good correlation between Au and Cu [2].
Exploration geologist(s) in charge	
	GTK: Veikko Keinänen; Rautaruukki: Aimo Hiltunen.
ORE	
Siting of gold	Associated with chalcopyrite [3].
Major opaques	Magnetite, chalcopyrite, pyrrhotite, pyrite [3,4].
Gangue	Diopside, quartz, hornblende, albite, microcline [3,4].
Enriched elements	Au, Cu, S, Fe [2,3].
GEOLOGY	
Major host rocks	Magnetite skarn or ironstone (3].
Minor host rocks	Diopside skarn [3].
Geological setting	The host rocks are part of the metasedimentary rock-dominated Matarakoski Formation of the >2050 Ma Savukoski Group of the Palaeoproterozoic Central Lapland Greenstone Belt [1,3,4].
Intrusives	Synorogenic granitoid adjacent to the mineralisation and its host rocks [1,3,4].
METAMORPHISM	
Metamorphic grade	Mineral assemblages given in [2,3] indicate mid-amphibolite facies conditions.
STRUCTURAL SETTING	
Structural style	Dominantly ductile [4].
Closest major shear	The NE-trending Äkäsjoki shear zone is 4 km SE from the mineralisation [1].
Controlling structure	The contact between the synorogenic granitoid and its country rocks? [1,3].
Veins	Quartz and carbonate veins [3].
GENETIC MODEL	Interpreted from [2,3,4]: This could be a case where the formation of magnetite skarn or ironstone "prepared ground": the a few metres to 140 m wide units of Fe-rich rock then formed a chemical trap and, perhaps, also a structural trap for auriferous solutions during peak(?) deformation and metamorphism.
FIGURES	[1]: Regional geology map.

References

1. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
2. Keinänen, V. 1995 Tutkimustyöselostus Kolarin kunnassa valtausalueella Kuervitikko 1 (Kaivosrekisterinumero 5082/1) suoritetuista kulta-kuparimalmitutkimuksista vuosina 1992-93. Geological Survey of Finland, unpublished report M06/2714/-95/1/10. 2 p. (in Finnish)
3. Keinänen, V. 1998. Personal communication on 19/8/1998.
4. Hiltunen, A. 1982. The Precambrian geology and skarn iron ores of the Rautuvaara area, northern Finland. Geological Survey of Finland, Bulletin 318. 133 p.

Name	***Vähäjoki***				
GENETIC TYPE	Skarn- or ironstone-hosted.				
LOCATION					
Geological domain	Lapland	**Belt**	Peräpohja Schist Belt		
Map sheet	2544 06	**X coordinate**	7334000	**Y coordinate**	2556000
Municipality	Tervola				
Nearest town, access	20 km E from Tervola. 2 km from a sealed road, a gravel road to the area.				
MINING					
Present holder	OPEN FOR ACQUISITION.				
Previous holders	Geological Survey of Finland (GTK) (1943-45), Otanmäki Oy / Rautaruukki Oy (1958-1970), Outokumpu Oyj (1970-1982).				
Status of development	Prospect.				
Resources	Best Au lodes: 0.1 Mt, 0.23 Mt and 1.0 Mt at 0.5 ppm Au [7].				
Best sections	3 m at 1.9 ppm Au, 3 m at 1.2 ppm Au [7].				
Extent of mineralisation	The lodes are in an area of about 1x2 km, and are open at depth of 100 m [3,5,7].				
Lodes	Ten or more distinct lodes with sizes from 0.04 to 1.0 Mt, comprising vein networks, blobs and bands [2,3,4,7].				
EXPLORATION					
Discovery	By GTK (1943) [4]: during exploration for Fe, diamond drilling into an area of strong magnetic anomalies.				
Exploration history	GTK (1943-45, 1978, 1987-1990) [1,2,3,4,5,6]: ground magnetic survey, bedrock mapping, diamond drilling. Low-altitude airborne geophysical survey in the area on 1978. Till geochemical and stratigraphy survey, survey of glacial erratic boulders 1987-1990. Otanmäki / Rautaruukki (1959-1969, 1975) [1]: ground magnetic, gravimetric and slingram surveys, bedrock mapping, percussion drilling through overburden to the surface of bedrock, till geochemical survey, diamond drilling. Outokumpu (1970-1982) [7]: ground magnetic, gravimetric and slingram surveys, bedrock mapping, percussion drilling through overburden to the surface of bedrock, till geochemical survey, diamond drilling, mineralogical studies.				
Drilling	GTK (1943-44) [3]: 10 diamond-drill holes, total 1318 m. Otanmäki / Rautaruukki (1959-1969) [7]: 18 diamond-drill holes, total 3713 m. Outokumpu (1981-1982): 24 diamond-drill holes, total 4361 m.				
Elements analysed	By XRF: major elements, Ba, Ce, Co, Cr, Cu, La, Mn, Mo, Nb, Ni, Pb, S, Sn, Sr, Ta, Th, U, V, W, Zn and Zr; by AAS: Ag, Au [7].				
Geophysical response	Strong magnetic and gravity anomalies [2,3,4,5,7].				
Exploration geologist(s) in charge					
	GTK: 1940s: Aimo Mikkola, 1990s: Seppo Rossi. Outokumpu: Erkki Korvuo.				
ORE					
Siting of gold	Native gold as inclusions in cobaltite and, possibly, “invisible” gold in chalcopyrite [7].				
Major opaques	Magnetite, pyrite, chalcopyrite, cobaltite [4,5,7].				
Minor opaques	Ilmenite, haematite, arsenopyrite, sphalerite, galena, mackinawite, linneaite, bornite, gold, graphite [4,5,7].				
Gangue	Tremolite-actinolite, chlorite, dolomite, calcite, biotite, talc, quartz, plagioclase, epidote, cummingtonite,spinel [2,3,4,5,7].				
Enriched elements	As, Au, CO_2, Cu, Fe, S [4,5,7].				
GEOLOGY					
Major host rocks	Mafic metavolcanic rock [2,7].				
Minor host rocks	Mica schist [2,7].				
Geological setting	The lodes are vein networks, blobs and bands in “amphibole skarn” and conformable bands in tremolite-chlorite schist and mica schist [2,3,4]. These rock units are within dolomite rock of sedimentary origin in the central part of the Palaeoproterozoic Peräpohja Schist Belt [2,3].				
METAMORPHISM					
Metamorphic grade	Lower-amphibolite facies(?) [2].				
STRUCTURAL SETTING					
Structural style	Brittle-ductile [2,3,4,5].				
Ore fabric	Granoblastic, massive to banded, brecciated [2,3,4,5].				
ALTERATION					
Proximal alteration	Mafic metavolcanic rock (main host): tremolite-actinolite-chlorite-biotite-quartz [2,3,4,5].				
GENETIC MODEL	Interpeted from [1,2,3,4,5,7]: This may be a case where the formation of magnetite skarn or ironstone “prepared ground”: the Fe-rich rock then formed chemical traps and, possibly, also structural traps for auriferous solutions during peak(?) deformation and metamorphism.				

Post-mineralisation modifications

Formation of cummingtonite porphyroblasts [7]: post-mineralisation thermal effect of later stage of regional metamorphism?

FIGURES [7]: Drilling profiles.

References

1. Rossi, S. 1998. Personal communication on 14/8/1998.
2. Mikkola, A: 1945. Malmitutkimukset Kemin-Rovaniemen liuskealueella kesällä 1945. Geological Survey of Finland, unpublished report M17/T-45/1 A.Mla. 19 p. (in Finnish)
3. Mikkola, A. 1949. Vähäjoen rautamalmi Tervolassa. Geological Survey of Finland, unpublished report M17/T-49/1. 3 p. (in Finnish)
4. Laitakari, A. 1943. Geologisen toimikunnan muistio Tervolan Vähäjoen rautamalmilöydöistä. Geological Survey of Finland, unpublished report Do. N:o 33. 2 p. (in Finnish)
5. Laitakari, A. 1944. Selostus Tervolan Vähäjoen rautamalmialueella vuosina 1943 ja 1944 suoritettujen tutkimusten tuloksista. Geological Survey of Finland, unpublished report Do. N:o 34. 7 p. (in Finnish)
6. Huhta, P., Johansson, P., Hakala, P. & Nenonen, J. 1990. Malminetsinnälliset maaperätutkimukset Tervolan Vähäjoella vuonna 1990. Geological Survey of Finland, unpublished report P23.4.012. 5 p. (in Finnish)
7. Korvuo, E. (1982) Vähäjoen rautamalmialueen tutkimukset 1979-1982. Lapin Malmi Oy, unpublished report. 49 p. (in Finnish)

Name	***Jouhineva (Pöllä)***
GENETIC TYPE	Granitoid-related (non-skarn) or orogenic ‘mesothermal’.
LOCATION	
Geological domain	Svecofennian **Belt** Raahe-Haapajärvi
Map sheet	2431 02 **X coordinate** 7107200 **Y coordinate** 2511500
Municipality	Kalajoki
Nearest town, access	20 km SW from Ylivieska, 115 km(?) SW from Oulu. A sealed road 7 km from the area, a gravel road 500 m from the area.
MINING	
Mining concession no.	2966/1a.
Present holder	Outokumpu Oyj.
Status of development	Prospect.
Resources	0.45 Mt at 0.81% Cu, 0.18% Co, 7.9 ppm Ag and 0.88 ppm Au [1,3].
Total in-situ gold	400 kg [1,3].
EXPLORATION	
Exploration history	Outokumpu (1978-84) [1,2,3]: survey of glacial erratic boulders, till geochemical survey, bedrock mapping. GTK (1984-) [3]: regional geochemical till and stream sediment survey, local till geochemical survey, low-altitude airborne electric and magnetic survey.
Elements analysed	Ag, Au, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, W, Zn [3].
Exploration geologist(s) in charge	Outokumpu: Esa Sandberg, Markku Isohanni.
ORE	
Major opaques	Arsenopyrite [3].
Gangue	Quartz, tourmaline [3].
Enriched elements	Ag, As, Au, B, Cu, Co, S [1].
GEOLOGY	
Major host rocks	Mafic and intermediate metavolcanic rocks(?) [3].
Geological setting	The mineralisation is in the country rocks of the synorogenic Rautio Batholith [3].
Intrusives	Synorogenic Rautio batholith whose composition varies from granite to diorite and monzodiorite [3].
STRUCTURAL SETTING	
Closest major shear	Two NW-trending major shear zones within the region [3], these may be part of the Raahe-Ladoga Zone.
Veins	Auriferous, tourmaline-arsenopyrite-bearing quartz veins [3].
ALTERATION	
General alteration	Silicification and carbonation of the host rock: formation of quartz micro-aggregates and carbonate dissemination [3].
GENETIC MODEL	Orogenic “mesothermal” or granitoid-related (non-skarn) deposit.

References

1. Isohanni, M. 1984. Malminetsintötyöt Kalajoen Jouhinevalla vuosina 1981-1984, 2342 02, 05. Outokumpu Oy, unpublished report 001/2342/MAI/84. 2 p. (in Finnish)
2. Sandberg, E. 1987. Kannuksen Antiojan ympäristön kullan raskasmineraalitutkimukset 1986. Outokumpu Oy, unpublished report 063/2342 02, 05/EAS/87. 1 p. (in Finnish)
3. Tenhola, M. 1990. Rautio batoliitin geokemialliset tutkimukset vuosina 1984-1988, karttalehdet 2431 Ylivieska, 2342 Sievi, 2324 Kannus, 2413 Kalajoki. Geological Survey of Finland, unpublished report S/41/2431/90. 27 p. (in Finnish)

Name	***Kopsa***				
GENETIC TYPE	Granitoid-related (non-skarn) or orogenic 'mesothermal'.				
LOCATION					
Geological domain	Svecofennian	**Belt**	Raahe-Haapajärvi		
Map sheet	2344 07	**X coordinate**	7075040	**Y coordinate**	2561050
Municipality	Haapajärvi				
Nearest town, access	4 km NW from Haapajärvi, 120 km SW from Oulu. A sealed road 2 km from the area, a gravel road to the area.				
MINING					
Exploration licence no.	2331/1-2, 3665/1, 5811/1.				
Present holder	Baltic Minerals Finland Oy (Glenmore Highlands & SES Finland JV(1995-)				
Previous holders	Outokumpu Oy (1940-1983), Geological Survey of Finland (GTK) (1983-).				
Status of development	Prospect.				
Resources	The intrusion [1,7]: 0.4 ppm Au, 0.08% Cu, 2.3 ppm Ag. Upper ore block: 25 Mt with 0.18% Cu, 0.57 ppm Au, 4 ppm Ag, including 1.1 Mt with 0.17% Cu, 0.57 ppm Au, 4 ppm As [1,7,11].				
Best sections	51 m at 2.47 ppm Au and 0.28 % Cu, including 10.6 m at 4.35 ppm Au, 0.47 % Cu [2]. Sorola satellite mineralisation: 2.6 m at 0.75% Cu, 73 ppm Ag and 1.4 ppm Au; 4 m at 0.9% Cu, 42 ppm Ag and 0.7 ppm Au [6].				
Extent of mineralisation	At least 450 x 800 m in plan, open at depth in 210 m [3]. Believed to be 100 x 200 x 400 m, but is irregular in shape, difficult to estimate [7]. 1200 x 400 x 100 m [11].				
Lodes	The mineralisation is of stockwork type with numerous crosscutting quartz veins and is formed of two parallel, gently-dipping or nearly flat, lodes within the tonalite [1,11]. The Au-Cu mineralisation is concentrated on steep, quartz vein-rich domains a few to 10 m wide, is distribured over a large part of the intrusion, and is consistent to the depths >175 m [5]. Extensive systems of arsenopyrite- and chalcopyrite-bearing quartz stockwork veining with Cu and Fe sulphides disseminated in wallrock [12].				
EXPLORATION					
Discovery	First glacial erratic boulders found 1937, this was followed by the discovery by GTK in outcrop on 1939 [1,7,11].				
Exploration history	Outokumpu (1940-41, 1964-66, 1971-73, 1977-78, 1981-83) [1,5,7,8,11]: Bedrock mapping, trenching, percussion and diamond drilling, till geochemistry, and ground magnetic, IP and VLF survey, pilot flotation processing study. GTK (1939, 1961, 1983-85) [6,11]; 1939: survey of glacial erratic boulders, bedrock mapping, diamond drilling. 1980's: exploration chiefly around the satellite mineralisation called Sorola (200 m from the main deposit): till geochemistry and stratigraphy, ground IP, electric (slingram) and magnetic survey, ore mineralogy study, diamond drilling. Baltic Minerals (1995-) [2,3,12]: diamond-, percussion- and RC-drilling program within an area of 450x800 m, trenching and ground magnetic survey, bedrock mapping in the surrounding areas, geochemical till survey.				
Drilling	1939-1941: 44 diamond-drill holes [11]. 1961: three diamond-drill holes [6]. 1970's: 50 diamond-drill holes and 200 percussion drill holes [1]. 1981-1983: 29 drill holes [2]. 1984-85: 13 diamond-drill holes in an irregular setting, 20-100 m apart, total 1256 m [6]. 1995-1997: 18 diamond- and 32 RC-drill holes, 4149 m and 2116 m, respectively. In addition, about 700, 5-7 m long, percussion drilling holes [2,3,12].				
Elements analysed	Ag, As, Au, Co, Cu, Mo, Pb, S, Te, W, Zn [1,2,3].				
Economic evaluations	A preliminary feasibility study 1981 [7].				
Geophysical response	IP and other electric methods define several anomalies in the area; the IP anomalies have the best response to the deposit [6].				
Primary dispersion	The entire intrusion is anomalous in Ag, As, Au and Cu. Au and As show good positive correlation [6,11].				
Exploration geologist(s) in charge					
	Outokumpu: Paavo Haapala, Markku Isohanni, Gabor Gaal.				
ORE					
Siting of gold	Mostly free grains of native gold with quartz, only a small volume of gold is in arsenopyrite [1].				
Major opaques	Chalcopyrite, arsenopyrite, pyrrhotite [1,6].				
Minor opaques	Loellingite, marcasite, pyrite, sphalerite, gold, molybdenite, cubanite, bornite, stannite, bismuth and several Bi-bearing sulphosalts [1,6].				
Gangue	Quartz, plagioclase, biotite, hornblende, microcline, scheelite [1,6].				
Ore composition	Diamond-drill core [4]: 3.80 ppm Au, 3.40 ppm Ag, 12000 ppm As, 6.7 ppm B, 505 ppm Ba, 168 ppm Bi, 30 ppm Co, 1630 ppm Cu, 14 ppb Hg, 5 ppm Mo, 20 ppm Ni, <2 ppm Pb, 88 ppm Rb, 10600 ppm S, 21 ppm Sb, 6.9 ppm Se, 130 ppm Sr, 5.800 ppm Te, 1.8 ppm Th, 1.5 ppm U, 66 ppm V, 500 ppm W, 65 ppm Zn; 72.0% SiO_2, 0.24% TiO_2, 10.6% Al_2O_3, 4.29% Fe_2O_3, 1.95% MgO, 2.33% CaO, 1.25% Na_2O, 3.62% K_2O, 0.041% P_2O_5, 1.54% LOI.				
Enriched elements	Au and Cu + Ag, As, Bi, K, Mo, S, Sb, Se, Te and W, depletion of Ca and Na [1,6].				
GEOLOGY					
Major host rocks	Main deposit: tonalite stock [1,2,3,4,5,6,11]; Sorola: metasedimentary rocks [6].				

Minor host rocks	Mica schist [5,6,11].
Geological setting	[1,11]: Porphyric, synorogenic tonalite stock, with surface extent of 0.6 x 2 km, is intruded into a volcano-sedimentary sequence. The location intrusion is controlled by the intersection of NW- and NE-striking faults. The mineralisation is of stockwork type with numerous cross-cutting quartz veins and is formed of two gently-dipping or nearly flat lodes within the tonalite. [5]: The mineralisation is in a quartz-vein stockwork, minor fractures and as dissemination in the stock and as dissemination in mica schist at the contact of the intrusion. The stock is late-orogenic, intruded into a Palaeoproterozoic supracrustal sequence near the SW edge of the Raahe-Ladoga Belt, a major suture zone in Finland.
Intrusives	Kopsa Tonalite stock, 1.93-1.86 Ga of age, hosting a porphyry-type Au-Cu mineralisation [1,2,3,4,5,6,7,8,9, 10,11].
METAMORPHISM	
Metamorphic grade	Lower-amphibolite facies(?).
Metamorphic mineral assemblage	Tonalite: plagioclase(-microcline)-quartz-biotite-hornblende [1]. Mica schist: quartz-plagioclase-biotite-muscovite-sillimanite-cordierite-K feldspar [11].
STRUCTURAL SETTING	
Structural style	Brittle(-ductile) [1,11,12].
Deformation history	The emplacement of the intrusion is assumed to have taken place between the formation of regional S2 and S3 schistosities [1,5].
Veins	Quartz vein network with an apparently inconsistent continuity [3,4].
ALTERATION	
General alteration	The tonalite is altered into granodioritic composition by K metasomatism and simultaneous depletion of Ca and Na. Also, silicification is significant in the style of alteration. In the mica schist, K alteration is displayed by formation of biotite and muscovite [1,5,11].
TIMING	Syn-magmatic, late-orogenic [1,2,3,11].
GENETIC MODEL	Porphyry Au-Cu type deposit [1,2,3]. However, details in outcrops suggest that the porphyry mineralisation is, possibly, overprinted by an epigenetic Au mineralisation under a brittle regime of deformation.
FIGURES	[1]: Cross section map. [7]: Drill logs. [8]: Local bedrock map.

References

1. Gaal, G. & Isohanni, M. 1979. Characteristics of igneous intrusions and various wall rocks in some Precambrian porphyry copper-molybdenum deposits in Pohjanmaa, Finland. Economic Geology, 74, 1198-1210.
2. Glenmore Highlands Inc. 1996. Initial assay results from Kopsa diamond drilling program. Press release 9/12/1996.
3. Glenmore Highlands Inc. 1997. Progress on Kopsa gold property. Press release18/8/1997.
4. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
5. Weihed, P. & Mäki, T. 1997. Volcanic hosted massive sulfide deposits and gold deposits in the Skellefte district and Western Finland. Geological Survey of Finland, Guide 41. 81 p.
6. Nikander, J. 1986. Tutkimustyöselostus Haapajärven kunnassa valtausalueella Kopsa 1, kaiv. rek. n:o 3665/1 suoritetuista kuparimalmi-tutkimuksista. Geological Survey of Finland, unpublished report M06/2344/-86/1/10. 18 p. (in Finnish)
7. Isohanni, H. 1982. Kaivoslain 19 pyk. mukainen tutkimustyöselostus: Haapajärvi, Kopsa. Outokumpu Oy, unpublished report 080/2344/ MAI/82. 3 p. (in Finnish)
8. Karvonen, T. 1975. Kaivospiirien Kopsa ja Vehka, kaivosrekisterinumerot 2331/1,2, hylkäämisilmoitus. A letter from Outokumpu Oy to the Ministry of Industry and Trade. 2 p. (in Finnish)
9. Mäkelä, M., Sandberg, E. & Rantala, O. 1988. Proterozoic, gold-bearing vein occurrences associated with the granitoids in western Finland. In: A. D. T. Goode et al. (comp.) Bicentennial Gold 88, Melbourne, Victoria, May 16-20, 1988: Extended abstracts. Poster programme. 1. Geological Society of Australia. Abstracts Series 23, 153-155.
10. Mäkelä, M., Sandberg, E. & Rantala, O. 1988. Geochemical exploration of gold-bearing veins associated with granitoids in western Finland. In: D. R. MacDonald & K. A. Mills (eds) Prospecting in Areas of Glaciated Terrain - 1988: Papers presented at the Eighth International Symposium on Prospecting in Areas of Glaciated Terrain, Halifax, Nova Scotia, August 28 - September 3, 1988: Canadian Institute of Mining and Metallurgy, 255-270.
11. Gaal, G. 1978. Haapajärven Kopsan ja Vehkan tutkimuksista vuosina 1939-1978. Outokumpu Oy, unpublished report 00/2344/GG/78. 49 p. (in Finnish)
12. Chakraborty, S. (1997) Personal communication 1/10/1997.

Name	***Kurula***
GENETIC TYPE	Orogenic 'mesothermal' type or granitoid-related (non-skarn).
LOCATION	
Geological domain	Svecofennian **Belt** Raahe-Haapajärvi
Map sheet	2431 08 **X coordinate** 7110740 **Y coordinate** 2527000
Municipality	Ylivieska
Nearest town, access	3 km NE from Ylivieska, 100 km SW from Oulu. Sealed highway 1 km from the area.
MINING	
Exploration licence no.	2350.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK) (1973-1980's).
Status of development	Prospect.
Best sections	5 m at 2.2 ppm Au and 0.1 % Co (average of a 5 m long section across mineralisation) [3,4,5].
Extent of mineralisation	30 x 30 x 4 m [3,4,5].
EXPLORATION	
Discovery	On 1970 by GTK: Arsenopyrite-bearing quartz-tourmaline rock in outcrop, containing 3.8 ppm Au, 26 ppm Ag, 0.1 % Co, 0.4 % Cu, found by an amateur prospector, samples provided to the GTK [3,4,5].
Exploration history	GTK (1970-1983) [1,3,4,5]: bedrock mapping, geochemical till mapping, ground IP, electric, magnetic and gravimetric survey, drilling, thin section investigations; local till sampling in 10 m network, in total 84 sample sites; round VLF-R survey; ore mineralogy study.
Drilling	GTK: 8 diamond-drill holes, in total 340 m [3,4,5].
Elements analysed	Au, As, Co, Cu, Ni, Pb, S, Zn [3,4,5].
Geophysical response	An IP response on minor shear zones whose relationship with Au mineralisation is unclear [3,4,5].
Primary dispersion	As, Au and Co anomaly with a lateral extent of 5-10 m around the deposit [3,4,5].
Exploration geologist(s) in charge	GTK: Esko Sipilä.
ORE	
Siting of gold	Native gold as inclusions in arsenopyrite-loellingite-cobaltite-saffrolite grains [1].
Major opaques	Arsenopyrite, loellingite [1,4].
Minor opaques	Cobaltite, pyrite, pyrrhotite, saffrolite, chalcopyrite, Bi-tellurides, gold [1,4,5].
Gangue	Quartz, tourmaline [1,4,5].
Ore composition	2.2 ppm Au, 0.1% Co (diamond-drill core; average of 5 m long section across mineralisation) [5]. Diamond-drill core [2]: 1.28 ppm Au, 0.160 ppm Ag, 18000 ppm As, 2900 ppm B, 309 ppm Ba, 19.1 ppm Bi, 1590 ppm Co, 291 ppm Cu, 59 ppb Hg, 26 ppm Mo, 151 ppm Ni, <2 ppm Pb, 68 ppm Rb, 9940 ppm S, 9.6 ppm Sb, 4.7 ppm Se, 272 ppm Sr, 2.500 ppm Te, 5.4 ppm Th, 3.7 ppm U, 110 ppm V, 600 ppm W, 57 ppm Zn; 60.0% SiO_2, 0.53% TiO_2, 13.1% Al_2O_3, 7.49% Fe_2O_3, 4.10% MgO, 1.62% CaO, 3.03% Na_2O23, 1.58% K_2O, 0.15% P_2O_5, 1.31% LOI.
Enriched elements	Au, As, B, Bi, As, Co, Cu, Hg, S, Sb, Se, Te, W [2,5].
GEOLOGY	
Major host rocks	Massive intermediate metavolcanic rock [4,5].
Minor host rocks	Felsic and intermediate metavolcanic and metasedimentary rocks [4,5].
Geological setting	The mineralisation is in contact between porphyric intermediate and fine-grained, pyroclastic(?) felsic metavolcanic rocks [4,5].
METAMORPHISM	
Metamorphic grade	Lower- or mid-amphibolite facies [4,5].
STRUCTURAL SETTING	
Structural style	Brittle-ductile.
Controlling structure	A shear zone at the contact between the volcanic rock units having a different competency [4,5].
Veins	A subvertical zone of auriferous quartz-tourmaline vein network [4,5].
ALTERATION	
Proximal alteration	Tourmaline formation [4,5].
GENETIC MODEL	Epigenetic quartz-tourmaline breccia formed in the contact zone of two rock types [3,4,5]. Either of orogenic 'mesothermal' or granitoid-related (non-skarn) type.

References

1. Csongradi, J., Dobosi, G. & Västi, K. 1983. Havaintoja Ylivieskan kulta- ja kobolttipitoisesta arseenimineralisaatiosta. Geologi 35, 47-50. (in Finnish)
2. Nurmi, P. A., Lestinen, P. & Niskavaara, H. 1991. Geochemical characteristics of mesothermal gold deposits in the Fennoscandian Shield, and a comparison with selected Canadian and Australian deposits. Geological Survey of Finland, Bulletin 351. 101 p.
3. Sipilä, E. 1977. Raportti Geologisen Tutkimuslaitoksen malmitutkimuksista Niemelänkylän valtausalueella Kurula 1, kaiv. rek. n:o 2350 1973-1975. Geological Survey of Finland, unpublished report M19/2431/-77/4/10. 11 p. (in Finnish)
4. Sipilä, E. 1983. Koboltti-kulta-aiheen (M19/2431/-88/1/10) jatkotutkimukset Ylivieskan Kurulassa 1978-83. Geological Survey of Finland, unpublished report M19/2431/-83/1/10. 20 p. (in Finnish)
5. Sipilä, E. 1988. Kurulan kulta-koboltti-turmaliinibreksian lisäselvitys Winkie-kairauksella 1985. Geological Survey of Finland, unpublished report M19/2431/-88/1/10. 4 p. (in Finnish)

Name	***Ritovuori (Sarvilampi)***				
GENETIC TYPE	Granitoid-related (non-skarn) overprinted by orogenic 'mesothermal'?				
LOCATION					
Geological domain	Svecofennian	**Belt**	Pihtiputaa Schist Belt		
Map sheet	3312 02	**X coordinate**	7028500	**Y coordinate**	3428900
Municipality	Pihtipudas				
Nearest town, access	1.5 km S from Pihtipudas, 130 km N from Jyväskylä. A gravel road to the area, 1 km to the sealed Highway 4.				
MINING					
Exploration licence no.	3514/1.				
Present holder	OPEN FOR ACQUISITION.				
Previous holders	Geological Survey of Finland (GTK) (1958-59, 1965-72, 1982-1986).				
Status of development	Prospect.				
Best sections	1.2 m at 3 ppm Au, 0.6 m at 22 ppm Au [1].				
Extent of mineralisation	Mineralised zone is about 1 km long and 200 m wide [1,2].				
EXPLORATION					
Discovery	On 1958 by GTK: survey of glacial erratic boulders led to the discovery of the mineralisation in outcrop [3].				
Exploration history	GTK (1958-59) [1,2,3]: survey of glacial erratic boulders, detailed bedrock mapping, diamond drilling.				
	GTK (1965-72) [1,2]: detailed bedrock mapping, ore mineralogy study.				
	GTK (1982-86) [3,4]: till stratigraphy and geochemistry, trenching, magnetic and slingram ground survey, detailed bedrock mapping, thin section investigations, mineralogical study on tourmaline, diamond drilling.				
Drilling	GTK (1958-59): 10 diamond-drill holes, total about 500 m [1,3].				
Elements analysed	By AAS(?) Ag, Au, Cu, Pb, Zn; by XRF: Si, Al, Fe, Mg, Ca, Na, K, Ti, Mn [3].				
Primary dispersion	Apparently, all tourmaline breccias and the late arsenopyrite veins contain, at least, 0.1 ppm Au [4].				
Exploration geologist(s) in charge					
	GTK, 1958-59: A.J. Laitakari, 1965-72: L. Aho, 1982-86: Jarmo Nikander.				
ORE					
Siting of gold	Only native gold which dominantly occurs in fractures of and between arsenopyrite grains, some gold as inclusions in pyrite [1,2].				
Major opaques	Arsenopyrite [1,2,3,4].				
Minor opaques	Pyrite, marcasite, sphalerite, pyrrhotite, chalcopyrite, loellingite, rutile, gold [1,2].				
Gangue	Quartz, tourmaline, scheelite [1,2,3].				
Ore composition	"Tourmaline skarn" [4]: 61.29% SiO_2, 1.10% TiO_2, 18.05% Al_2O_3, 5.51% Fe_2O_3tot, 0.51% MgO, 5.57% CaO, 0.82% Na_2O, 0.00% K_2O, 0.00% MnO.				
Enriched elements	As, Au, B, S, W [3].				
Ore fluid	Tourmalinisation-related, B-rich fluid, possibly, came from the plutons near by [4].				
GEOLOGY					
Major host rocks	Mafic, intermed. and felsic metavolcanic rocks [1,2,3,4].				
Geological setting	Dominantly calc-alkaline, locally tholeiitic, subaerial(?) metavolcanic rocks and metasedimentary rocks which were deposited in an island-arc setting and intruded by syn-orogenic granodioritic to tonalitic plutons and intermediate to mafic dikes [3,4].				
Intrusives	Syn-orogenic (1.8-1.86 Ma) granodiorite pluton to the east of the area; intermediate and mafic, metamorphosed dikes cross cut the metavolcanic host rocks [3,4].				
METAMORPHISM					
Metamorphic grade	Lower-amphibolite facies, peak metamorphism at T = 500-600°C, p = 3.5±0.5 kbar [4].				
Metamorphic mineral assemblage	Banded metavolcanic rocks: microcline-quartz-biotite-hornblende-chlorite-magnetite-titanite-epidote [1,3,4]. Mafic rocks: plagioclase (An30-40)-hornblende-biotite-quartz-epidote-titanite-magnetite-chlorite-apatite[1,3,4]. Metasedimentary rocks: andalusite-cordierite-quartz-muscovite-garnet [4].				
STRUCTURAL SETTING					
Closest major shear	A NW-trending, >100 km long shear zone a few km to the NE of the mineralisation [3,4].				
Deformation history	At least three major stages [4]: D2 post-dates tourmalinisation, D3 is related to formation of localised shear zones.				
Veins	Auriferous, arsenopyrite-bearing quartz veins [1,2,3,4].				
ALTERATION					
General alteration	Intense tourmalinisation, feldspars and biotite replaced by tourmaline [3,4]. It is unclear if this actually is related to the early gold mineralisation, which is overprinted by the vein-gold mineralisation. Sericitisation of plagioclase and chloritisation of hornblende [4]: these are retrograde changes, and may be related to the quartz veins or post-date them. Weak sulphidation is related to the quartz veins: pyrrhotite-chalcopyrite-pyrite dissemination in the wall rocks [1].				

Proximal alteration Felsic rocks: quartz-plagioclase-tourmaline-microcline-biotite-calcite-titanite-epidote-diopside-muscovite [4].

Mafic rocks: tourmaline-quartz-hornblende [4].

Most intense tourmalinisation in all rocks: tourmaline-diopside-microcline-hornblende-quartz ± pyrite, biotite, titanite, chlorite, plagioclase, epidote [4].

Proximal alteration related to quartz veins: monomineralic hornblende zone 10 cm wide [4].

GENETIC MODEL Early, granitoid-related gold mineralisation with tourmalinisation: fluids from the local syn-orogenic granodiorite(s); this is overprinted by arsenopyrite-bearing quartz veins (tourmaline detected as inlusions in arsenopyrite) which, possibly, remobilised and concentrated gold during the late stages of deformation [3,4].

Post-mineralisation modifications

Retrograde sericitisation and chloritisation [4].

FIGURES [1]: Regional and local surface geology maps.
[4]: Local surface geology map, outcrop photographs and thin section photomicrographs.

References

1. Aho, L. 1973. Pihtiputaan Ritovuoren malmimineralogiasta. Geological Survey of Finland, unpublished report M19/3312/73/1/10. 36 p. (in Finnish)
2. Aho, L. 1975. Ore mineralization at Ritovuori, Pihtipudas, Central Finland. Geological Survey of Finland, Bulletin 275. 20 p.
3. Nikander, J. 1987. Malmitutkimukset Pihtiputaan kunnassa valtausalueella Sarvilampi 1, kaiv. rek. n:o 3514/1. Geological Survey of Finland, unpublished report M06/3312/-87/1/10. 4 p. (in Finnish)
4. Grönholm, S. 1987. Pihtiputaan Ritovuoren suprakrusiset kivet ja niiden turmaliiniutuminen. Unpublished MSc thesis, Department of Geology, University of Turku. 91 p. (in Finnish)

Name	***Kaarestunturi***
GENETIC TYPE	Palaeoplacer.
LOCATION	
Geological domain	Lapland **Belt** Kumpu Group
Map sheet	3714 01 **X coordinate** 7497000 **Y coordinate** 3467600
Municipality	Sodankylä
Nearest town, access	25 km NW of Sodankylä, 120 km N of Rovaniemi. 10 km from a sealed road, 2 km from a gravel road.
MINING	
Exploration licence no.	2878/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK) (1972-1985).
Status of development	Prospect.
Best sections	Average Au content within a lens is up to 5 ppm, but locally exceeds 10 ppm (up to 22 ppm) [2,3].
Lodes	A set of up to 30 m long and 3 m thick lenses [1,3].
EXPLORATION	
Discovery	GTK, early 1980s: during exploration project targeting on palaeoplacer gold deposits: Au analyses of conglomerate samples taken on 1972 [1,2,3].
Exploration history	GTK (1972-1985) [1,2,3,5]: bedrock mapping, till geochemical survey, trenching, channel sampling, percussion and diamond drilling.
Drilling	GTK (1981-1985) [3]: Five diamond-drill holes, total 421 m.
Elements analysed	Au and Pd by GFAAS; As, Co, Cr, Cu, Fe, Mn, Ni, Pb, S, Zn by ICP and AAS; REE, Th and U by NAA [3].
Primary dispersion	No correlation between Au and As, Co, Cr, Cu, Fe, Mn, Ni, Pb, S or Zn [1].
Exploration geologist(s) in charge	GTK: Osmo Auranen, Ilkka Härkönen.
ORE	
Siting of gold	Free, palaeo-detrital gold, with grain size of 0.03-0.4 mm, and rare Au-Pd alloy grains occur in the matrix of the conglomerate [3,5].
Fineness	About 5% Ag [3].
Major opaques	Magnetite, haematite [1,2].
Minor opaques	Uraninite, pyrite, ilmenite, rutile, gold, silver, an Au-Pd alloy [2,5].
Gangue	Quartz, tourmaline, monazite, zircon, titanite [2].
Ore composition	1.19-10.9 ppm Au, 1.9-8.0 ppm U, 5.8-48.0 ppm Th [3].
GEOLOGY	
Major host rocks	Conglomerate [1,2,3]
Minor host rocks	Quartzite [1,3]
Geological setting	The quartzites and conglomerates, which are part of the <1913 Ma Kumpu Group [4], are deposited discordantly on greywackes and carbonate metasedimentary rocks which, in turn, lay discordantly on >2050 Ma mafic and ultramafic metavolcanic rocks [3,4]. The most consistent gold grades are in a 30-60 m thick conglomerate sequence formed in a delta environment [2,5].
METAMORPHISM	
Metamorphic mineral assemblage	Quartz-muscovite [2].
STRUCTURAL SETTING	
Structural style	Brittle [5].
Deformation history	Two major phases of folding [3,4].
Ore fabric	Blastoclastic.
ALTERATION	
General alteration	No alteration described [1,2,3,4].
GENETIC MODEL	Palaeoplacer; probable sources for gold are the “mesothermal” lode-gold deposits in the greenstones stratigraphically below the metasedimentary host rocks [1,2,3,5].
Post-mineralisation modifications	All metamorphism and deformation [1,2,3,4].
FIGURES	[3]: Drilling plan. [4]: Regional geology map.

References

1. Härkönen, I. 1984. Tutkimus kullan esiintymisestä Keski-Lapin alaproterotsooisissa, karkeissa, klastisissa sedimenteissä 1978-1983. Geological Survey of Finland, unpublished report. M19/3714/-84/1/10. 85 p. (in Finnish)
2. Härkönen, I. 1984. The gold-bearing conglomerates of Kaarestunturi, Central Finnish Lapland. In: R.P. Foster (ed.) Gold ’82; the Geology, Geochemistry and Genesis of Gold Deposits. Geological Society of Zimbabwe, Special Publication 1, 239-247.
3. Härkönen, I. 1985. Tutkimustyöselostus Sodankylän kunnassa valtausalueella Kaarestunturi 1, kaiv. rek. n:o 2878/1, suoritetuista malmitutkimuksista. Geological Survey of Finland, unpublished report M06/3714/-85/1/10. 6 p. (in Finnish)
4. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
5. Härkönen, I. 1986. Gold in the Proterozoic conglomerates of Finnish Lapland. Terra Cognita 6, p. 538.

Name	***Outapää***
GENETIC TYPE	Palaeoplacer.
LOCATION	
Geological domain	Lapland **Belt** Kumpu Group
Map sheet	3712 06 **X coordinate** 7514000 **Y coordinate** 3437700
Municipality	Kittilä
Nearest town, access	30 km east from Kittilä. 15 km from a sealed road, a gravel road adjacent to the area.
MINING	
Exploration licence no.	3529/1.
Present holder	OPEN FOR ACQUISITION.
Previous holders	Geological Survey of Finland (GTK) (1983-1988).
Status of development	Prospect.
Best sections	1 m at 5.9 ppm Au, several separate 1 m sections at 1-4 ppm Au [2].
EXPLORATION	
Discovery	GTK (1978-1983) [2]: During exploration project for palaeoplacer gold deposits. Regional lithogeochemical sampling indicated potential for gold in the area; the mineralisation was detected by outcrop sampling.
Exploration history	GTK (1978-1988= [1,2]: Bedrock mapping, till geochemical survey, trenching, channel sampling, percussion and diamond drilling.
Drilling	GTK (1983, 1986) [2]: Six diamond-drill holes, total 862 m.
Exploration geologist(s) in charge	
	GTK: Ilkka Härkönen.
ORE	
Siting of gold	Free, chiefly palaeo-detrital gold with grain size of 0.03-0.4 mm and, locally, remobilised gold particles in the matrix of the conglomerate [1,2,4].
Major opaques	Magnetite, haematite [2].
Minor opaques	Gold; no detrital sulphides detected [2].
Gangue	Quartz [2].
GEOLOGY	
Major host rocks	Conglomerate [1,2,3].
Minor host rocks	Greywacke [1].
Geological setting	The quartzites and conglomerates, which are part of the <1913 Ma Kumpu Group [3], are deposited discordantly on >2050 Ma mafic and ultramafic metavolcanic rocks [1,3]. The depositional environment is, possibly, a graben and the host rock, apparently, a fanglomerate deposited in a fluvial fan [1,4].
METAMORPHISM	
Metamorphic mineral assemblage	Quartz-muscovite [1,2].
STRUCTURAL SETTING	
Structural style	Brittle [4].
Deformation history	Two major phases of folding [1,2].
Ore fabric	Blastoclastic.
ALTERATION	
General alteration	No alteration [1,2,4].
GENETIC MODEL	Palaeoplacer; probable sources for gold are the “mesothermal” lode-gold deposits in the greenstones stratigraphically below the metasedimentary host rocks [1,2,4].
Post-mineralisation modifications	
	All metamorphism and deformation; minor, local remobilisation and precipitation of gold [1,2]
FIGURES	[3]: Regional geology map. [2]: Topography and drilling plan.

References

1. Härkönen, I. 1984. Tutkimus kullan esiintymisestä Keski-Lapin alaproterotsoisissa, karkeissa, klastisissa sedimenteissä 1978-1983. Geological Survey of Finland, unpublished report M19/3714/-84/1/10. 85 p. (in Finnish)
2. Härkönen, I. 1988. Tutkimustyöselostus Kittilän kunnassa valtausalueella Outapää 1, kaiv. rek. n:o 3529/1, suoritetuista malmitutkimuksista. Geological Survey of Finland, unpublished report M06/3712/-88/2/10. 3 p. (in Finnish)
3. Lehtonen, M. I., Airo, M-L., Eilu, P., Hanski, E., Kortelainen, V., Lanne, E., Manninen, T., Rastas, P., Räsänen, J. & Virransalo, P. 1998. Kittilän vihreäkivialueen geologia. Lapin vulkaniittiprojektin raportti. Summary: The stratigraphy, petrology and geochemistry of the Kittilä greenstone area, northern Finland. A report of the Lapland Volcanite Project. Geological Survey of Finland, Report of Investigation 140. 144 p.
4. Härkönen, I. 1986. Gold in the Proterozoic conglomerates of Finnish Lapland. Terra Cognita 6, p. 538.